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Influence of beer color on bitterness perception: A consumer-sensory study

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Purpose

- Determine the differences (if any) of using black malt vs. Weyermann Sinamar® during darkening beer color

- Determine whether beer color impacts the perceived bitterness of beer

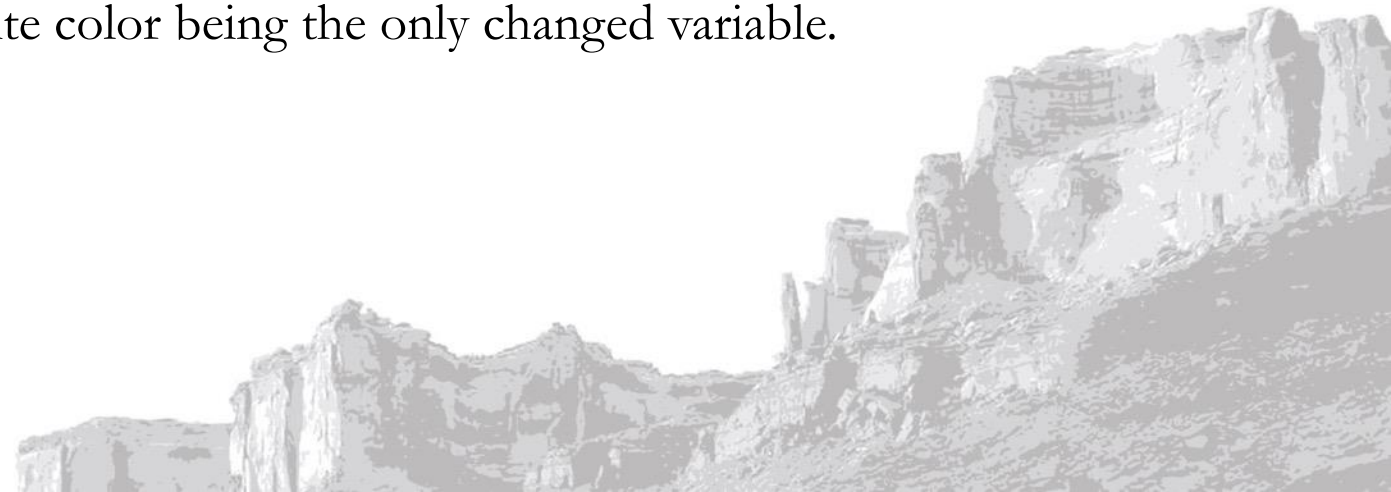
Hypotheses

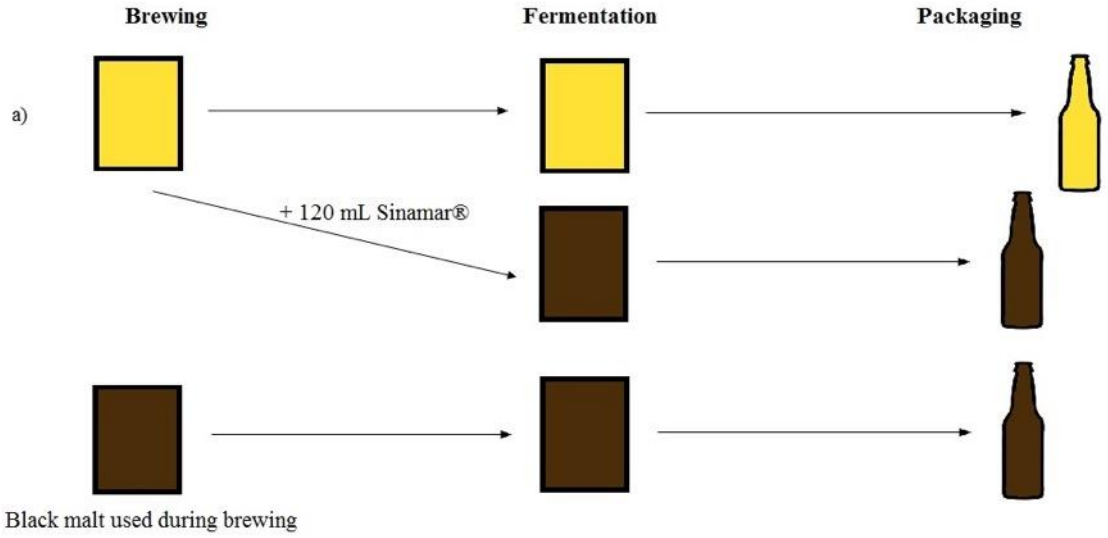
Throughout this study it is expected that:

I. There will be no chemical or perceived sensory difference between darkening beer with Sinamar and a dark malt during brewing.

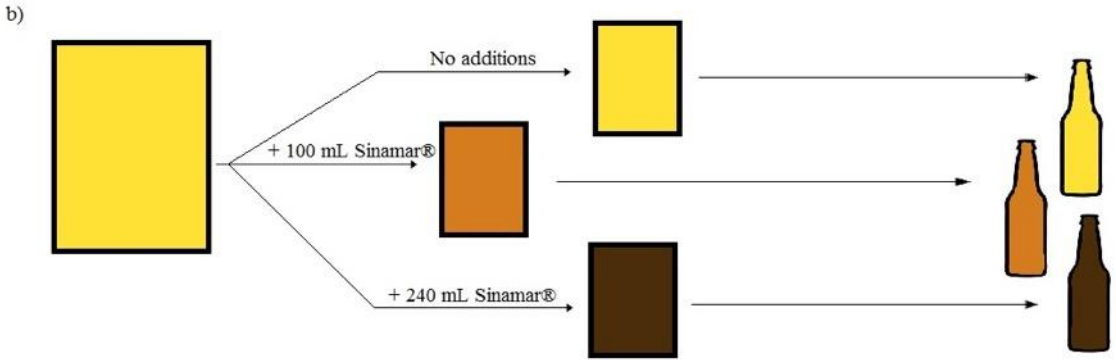
II. Beer brewed with darkening agents will not be discriminable from un-darkened beer when color is obscured.

II. Consumers in Philadelphia (represented by Drexel University students, staff, and faculty) will perceive a darker colored beer as more bitter, despite color being the only changed variable.





Experiment 1: Darkening Techniques

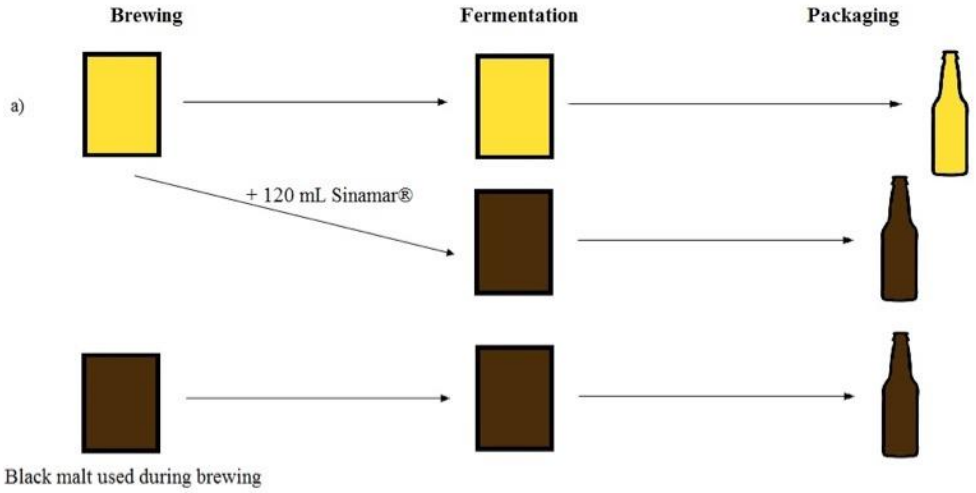


Experiment 2: Color Perception

Experiment 1: Darkening Techniques

Methods

- Beer Production
  - Standard American Pale Ale
  - Base (L), Dark Sinamar (DS), Dark Grain (DG)



- Biological/Chemical Analysis
  - Microbiological Testing
    - Various wild yeast and bacteria medium
    - 25°C, 6% CO_2, 120 hours
  - Color (SRM)
  - Bitterness (IBU)

Methods

Sensory Evaluation

- Exempt Institutional Review Board (IRB) # 3 Adult/Social Behavioral)
- Discrimination test
  - Yards Brewing Company (Philadelphia, PA)
  - Company employees ($n = 24$)
  - Y vs. DG, Y vs. DS
  - Data was analyzed following the normal approximation to the binomial distribution ($p < 0.05$)
    - With null-hypothesis chance of a correct answer $p_0 = 1/3$

Results

Biological/Chemical Analysis

- Based on gravity readings all ABV ≈ 5.5%

	L	DG	DS
LWYM	+	+	+
LCSM	-	-	-
WLD	-	-	-
HLP	-	-	-

	L	DG	DS
Color (SRM)	13.4 ± 0.2	54.0 ± 0.3	54.4 ± 0.3
Bitterness (IBU)	43.4 ± 0.8	44.0 ± 0.9	43.7 ± 0.2

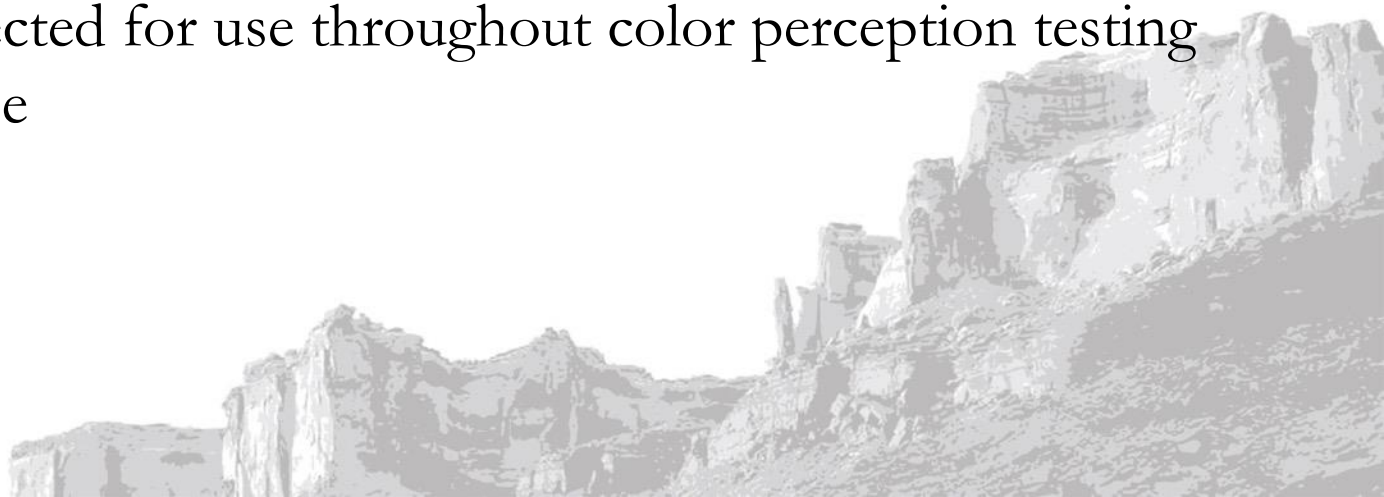
Results

Sensory Evaluation

- 24 subjects participated in 2 different triangle tests
- 1-tailed (upper) critical number of correct decisions for a binomial distribution with $p_0 = 1/3$ and $n = 24$ is 13 correct responses
- L vs. DG: 12/24
- L vs. DS: 9/24
- There is not evidence of significant discriminability between the Y and DG or Y and DS beers

Conclusions

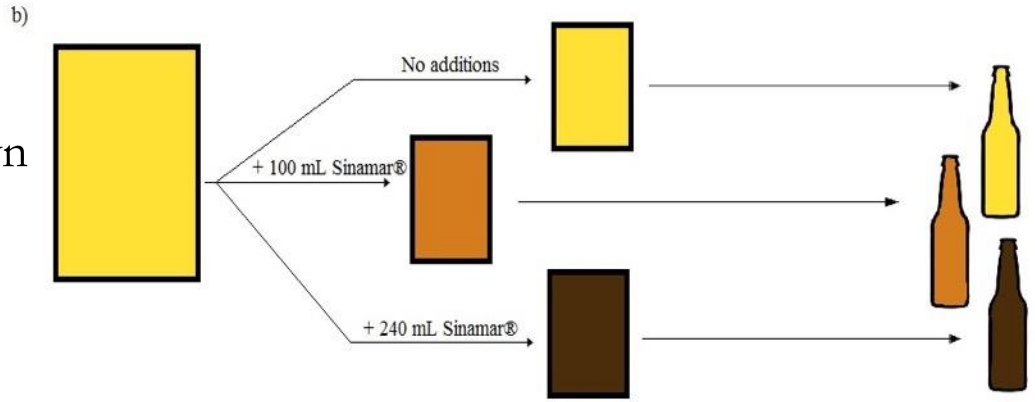
- The initial darkening test was completed to compare two potential methods to be used later in this study
- Both the use of Sinamar and addition of black malt during brewing have been found to effectively darken beer color while remaining apparently flavor neutral (at normal-use levels)
- No statistically significant difference ($p < 0.05$) between darkening methods
- Sinamar was selected for use throughout color perception testing for its ease of use



Experiment 2: Color Perception

Methods

- Beer Production
  - Standard American Pale Ale
  - Darkened with Sinamar
  - Light Yellow (L), Medium Brown (M), Dark Black (D)



- Biological/Chemical Analysis
  - Microbiological Testing
    - Various wild yeast and bacteria medium
    - 25 °C, 6% CO_2, 120 hours
  - Color (SRM)
  - Bitterness (IBU)
  - Additional testing
    - Carbonation, fill, and pH

Methods

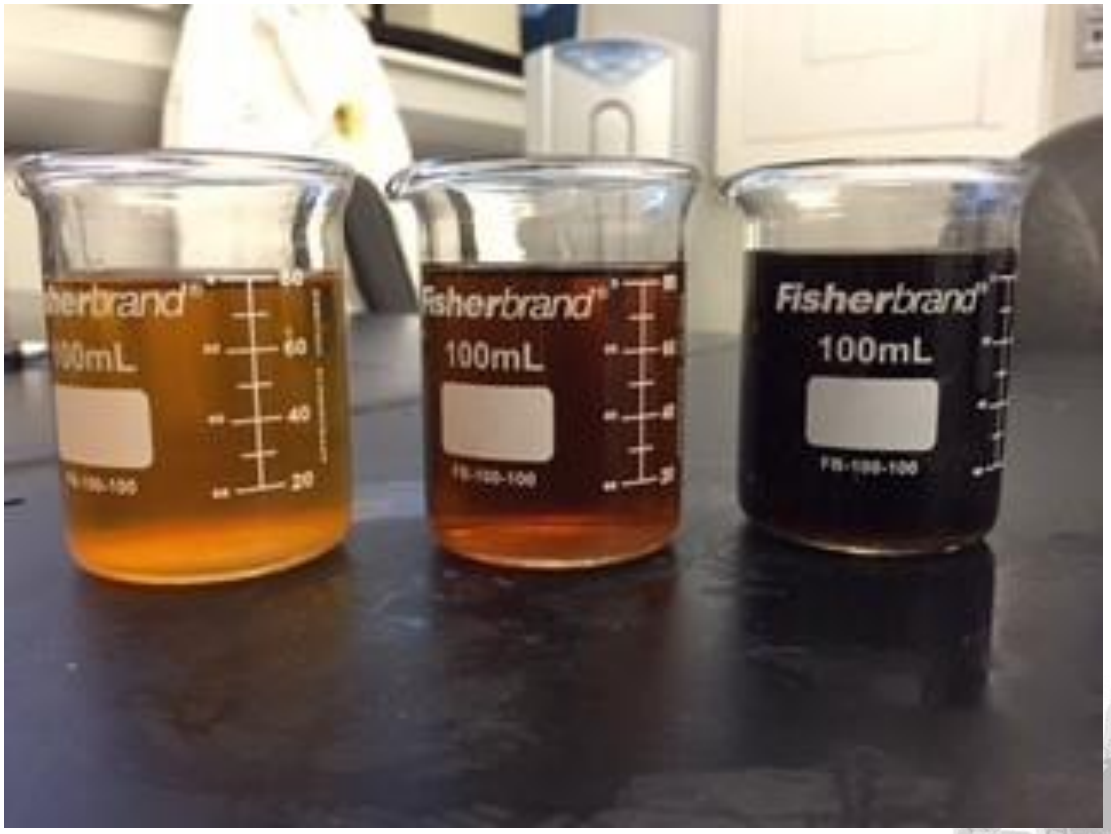
Sensory Evaluation

- Exempt Institutional Review Board (IRB) # 3 (Adult/Social Behavioral)
- Discrimination Test
  - Yards Brewing Company (Philadelphia, PA)
  - Company employees ($n = 21$)
  - Three Blind Triangle Tests (L, M, and D) – repeated twice
  - Data was analyzed following the normal approximation to the binomial distribution ($p < 0.05$)
    - With null-hypothesis chance of a correct answer $p_0 = 1/3$

Methods

- Consumer Test
  - Drexel University (Philadelphia, PA)
  - Faculty, staff, and students ($n = 85$)
  - Rate Taste Attributes
    - Bitter, sweet, sour, and salty taste
    - Scale from 1 to 15 (no taste to extreme taste)
  - Liking on 9-point hedonic scale
    - "dislike extremely" to "like extremely"
  - Demographic information
  - One-way analysis of variance (ANOVA) with repeated measures ($p < 0.05$)
    - Analyzed with "R" statistical program

Results



L M D

Results

- Biological/Chemical Analysis
  - Based on gravity readings all ABV ≈ 5.5%

	L	M	D
LWYM	+	+	+
LCSM	-	-	-
WLD	-	-	-
HLP	-	-	-

	L	M	D
Carbonation (Volumes CO_2)	2.85 ± 0.03	2.81 ± 0.03	2.82 ± 0.02
Fill (mL)	646 ± 2	642 ± 3	645 ± 3
pH	4.31 ± 0.01	4.32 ± 0.03	4.40 ± 0.01
Color (SRM)	13.0 ± 0.2	30.7 ± 0.3	55.1 ± 0.4
Bitterness (IBU)	45.2 ± 0.3	45.2 ± 0.2	45.2 ± 0.1

Results

Sensory Evaluation

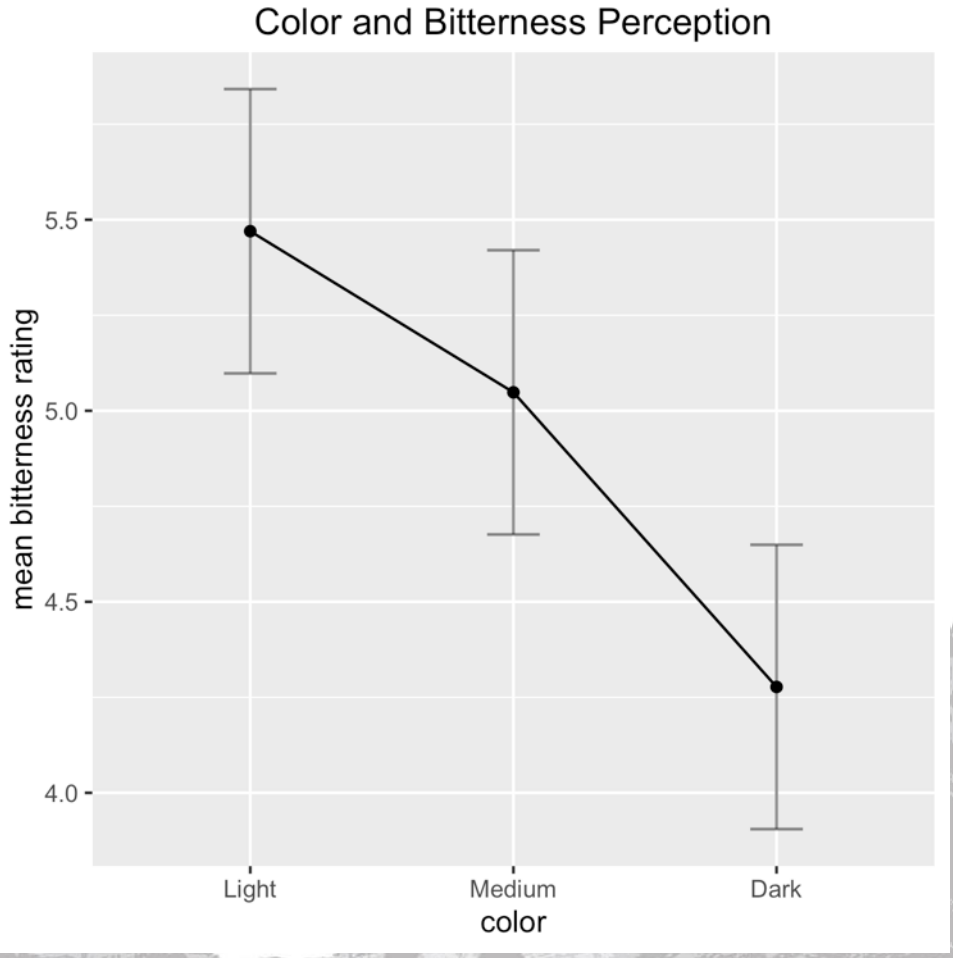
- Discrimination Test
  - 21 subjects participated in 3 triangle tests, replicated twice
  - Independence of repeated tested between subjects was tested
  - Statistically independent, results pooled
  - No results found to be significant
  - At two concentrations, Sinamar had no apparent impact on flavor profile of beer

Statistical analysis for second triangle test (Sinamar-darkened beers)				
Triangle Test Samples	Replications (# correct)		Independent Replications?	Overall Significance
Light vs. Dark	7/21	11/21	$11 < n_{crit} (=13)$: NS	$18 < n_{crit} (=20)$: NS
Light vs. Medium	8/21	4/21	$8 < n_{crit} (=10)$: NS	$12 < n_{crit} (=20)$: NS
Medium vs. Dark	8/21	9/21	$9 < n_{crit} (=13)$: NS	$17 < n_{crit} (=20)$: NS

Results

Sensory Evaluation

- Consumer Test
  - No significant impact of color on sweet, salty, sour, or liking ratings
  - Color had **significant** effect on perception of bitterness
  - Light yellow beer was perceived as most bitter
    - $F(2,164) = 5.15, p = 0.007$

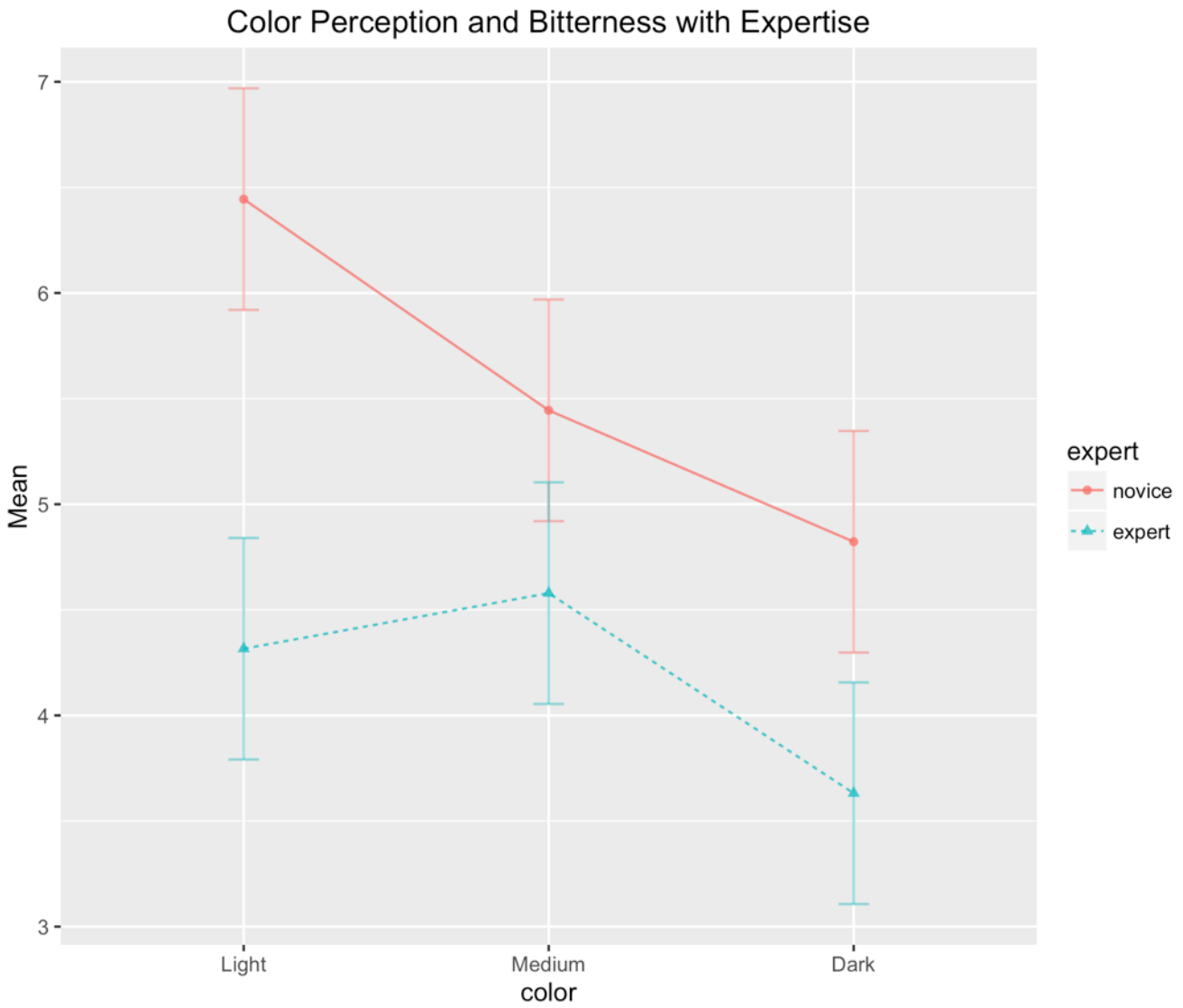


Results

Sensory Evaluation

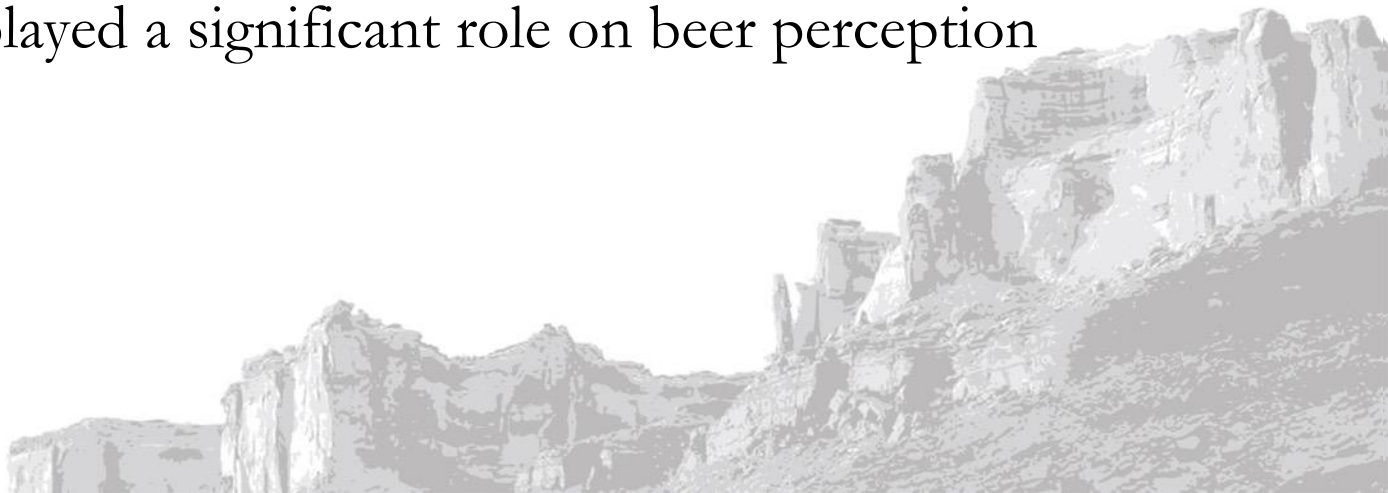
- Consumer Test
  - Further analysis through "expertise" groups
    - Based on demographic information (beer liking and consumption habits)
    - "Experts" $n = 51$, "Novices" $n = 34$
  - Bitterness perception effect by both expertise and beer color
    - Between-subjects variable (expertise): $F(1,81) = 5.73$, $p = 0.019$
    - Within-subjects variable (color): $F(2, 162) = 5.18$, $p = 0.007$
    - "Novice" group perceived beer as more bitter in general

Effect of beer color and expertise level on perception of bitterness



Conclusions

- Beer can be darkened in color with both black malt or Sinamar with no detectable change in flavor
- When color was visible, lighter yellow beer was perceived as significantly ($p < 0.05$) more bitter than a darker black beer
  - "Novice" beer drinkers seemed to drive sensory results
  - Experience played a significant role on beer perception



Further Work

- Evaluate effect of color on other desireable flavors
  - "malty" or "fruity"
- Intensity of off-flavors
  - Diacetyl, acetaldehyde, trans-2-nonenal
- Style perception
  - Between or Within
- Expected flavors
- Bottles vs. cans
- Specific selection of participants
  - Beer drinking/liking habits, training, etc.

Acknowledgements

- Drexel University, Center for Hospitality and Sports Management
- Yards Brewing Company
- Dogfish Head Craft Brewery

Thank You! Questions?