Brewing India Pale Ales

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BA Style Guideline

- Medium-high to intense hop bitterness, flavor, and aroma
- Medium to high alcohol content
- American hop character
- High mineral content water = crisp & dry
- Pale gold to deep copper color
- Medium maltiness, medium body
- Fruity ester flavors/aromas moderate to strong

Water

- Carbon filters to strip chlorine
- High sulfate water (calcium and magnesium)
  - More intense bitter character
  - Better clarity
  - Stability
- Chloride
  - Mellows flavor, adds fullness and roundness
  - Clarity
  - Lowers pH
- Water to grain ratio

Malt

- "Soul of the Beer"
  - Provides body, sweetness, color, and the starches to be converted to fermentable sugars
- Large pale malt base (85-97%)
- Specialty malt (3-15%)
  - Limited use in IPA brewing
- Crystal malt (10-60 °L)
  - Nothing more than 60 °L is normally used
- Dark Malts (.5-1%)

Brewing Sugars

- Creates drier and lighter colored beer
- Sucrose
  - Disaccharide composed of glucose and fructose
  - More commonly used in British IPA
- Powdered dextrose sugar (5-10%)
  - Glucose derived from enzymatically hydrolyzed cornstarch
  - Added to beginning of boil

Mashing

- Gentle mash mixing
  - Course crush
  - Preserve husks
- Alpha and beta amylase enzymes
  - Beta amylase: 130-140 °F
  - Alpha amylase: 150-160 °F
  - Two mash rest temperatures
- Time
- Temperature
- Mash off

Mash Hopping vs. First Wort Hopping

- Mash Hopping
  - Higher pH in the mash creates non-volatile compounds in the wort
  - Thought to lend a more rounded bitterness
  - Whole hops help in lautering
- First-Wort Hopping
  - Volatile compounds bind to malt components
  - Hops have longer contact time

Hop Products

- Only female plants flower
- Hop varieties
  - Low alpha 1.5-5% : Hallertau, Saaz, and Goldings
  - High alpha 17-18% : Warrior, Summit, Apollo
- Hop products
  - Whole
  - Pellets
  - Extracts
    - Becoming more accepted by craft brewers
    - Better products are available than in the past
    - Reduces kettle solids and increases efficiency

Chemical Composition of Hops

- Alpha Acids
  - Humulone 40-80%
  - Cohumulone 14-50%
  - Adhumulone 5-15%
- Cohumulone harshness
  - Can start at levels over 30%

Iso-Alpha Acids

- Alpha acids must be isomerized through boiling to dissolve in wort
- Isomerization factors
  - Temperature
  - Length of boil
  - Vigor
  - Pressure of boil
  - Kettle design
  - Altitude
- Iso-alpha acids contribute significantly to foam retention

Hop Utilization % Formula

- Hop utilization = $\frac{\text{iso-alpha acids in wort x 100}}{\text{alpha acids added to the brew}}$

- Wort analysis helps calculate hop utilization
- Hop addition timing
- IBUs drop as much as 33% during fermentation
- Balancing hop flavor/aroma with utilization
- Over-hopping

Factors Affecting Hop Utilization in Kettle Boil

Change	Typical hop utilization, impact on bitterness obtained
Hop cones, 12 P wort, 90 min boil	20-30% utilization
Hop pellets	Increase, 25-35% utilization
Hop extract	Increase, 30-40% utilization
Increase boil time	Increase
Increase wort pH	Increase
Decrease gravity	Increase
Increase hopping rate	Decrease. Bitterness will increase, but not linearly.

IPA: Brewing Techniques, Mitch Steele

Essential Hop Oils

- Contribute hop aroma and flavor
  - Myrcene
    - Provides important late hop flavor and aroma
    - Most abundant oil (30-60%)
    - Evaporates quickly
  - Humulene
  - Caryophyllene
- Hop oils are volatile
  - Lost during the boil

Hop Recipe Design Considerations

- Hop variety
- Desired hop flavor and aroma
- Bitterness level
- Kettle hop utilization
- Impact of late hop additions on flavor and aroma
- Dry hopping

Single Additions vs. Multiple Additions

- Breweries hop at both extremes of the spectrum
  - Single addition
  - Multiple additions
  - Continual additions
- Practicality can influence decision

Hopping in the Kettle, Hopback, & Whirlpool

- Kettle Hopping
  - Bittering, flavor, and aroma
- Hopback Hopping
  - Significant hop flavor and aroma
  - Use high quality aromatic hops
- Whirlpool Hopping
  - A significant amount of bitterness can be obtained
  - Isomerization of alpha acids occurs at temperatures above 185 °F
  - Quickly removing wort preserves volatile oils

Fermentation

- Yeast
  - Strain selection
  - Temperature
  - Nutrients
  - O2 levels
    - 9-15 ppm dissolved oxygen at time of yeast pitching
- Pitching Rates
  - 16 million cells per 16° plato
  - 20 million cells per 20° plato
- Fermentation Hopping

Fermentation Byproducts

- Diacetyl
  - Buttery flavor with slick mouthfeel
  - Diacetyl reduction is increased when:
    - Beer pH is lowered
    - Diacetyl rest – raise temps
    - High concentration of yeast in suspension
    - Starting with healthy yeast

Fermentation Byproducts

- Acetaldehyde
  - Green apple flavor
  - Created during excessive post-fermentation yeast contact
    - Lack of nutrients stresses yeast
  - Reduced with warmer temps and racking beer off yeast
- Fusel Alcohols
  - Produced by excessive yeast growth
  - Reduce sugar additions, aeration and fermentation temps

Fermentation Byproducts

- Ester Formation
  - Higher pitch rate = lower growth = more esters
  - Higher gravity wort = more esters
  - Tall fermenters = more pressure = less esters
  - Decreased aeration = lower growth = more esters

Dry Hopping

- Time
  - 5-15 days
- Temperature
  - Warm
- Contact
  - Rouse with CO2
- Hop varieties
- Dry Hopping Methods
  - Top port
  - Slurry recirculation
  - Hop cannon

Filtration

- Strips
  - Color
  - Body
  - Mouthfeel
  - Bitterness
  - Aroma
  - Stability (shelf life)
- Fining
  - Gelatin and silica

Yeast Is Good

- Drink Fresh!


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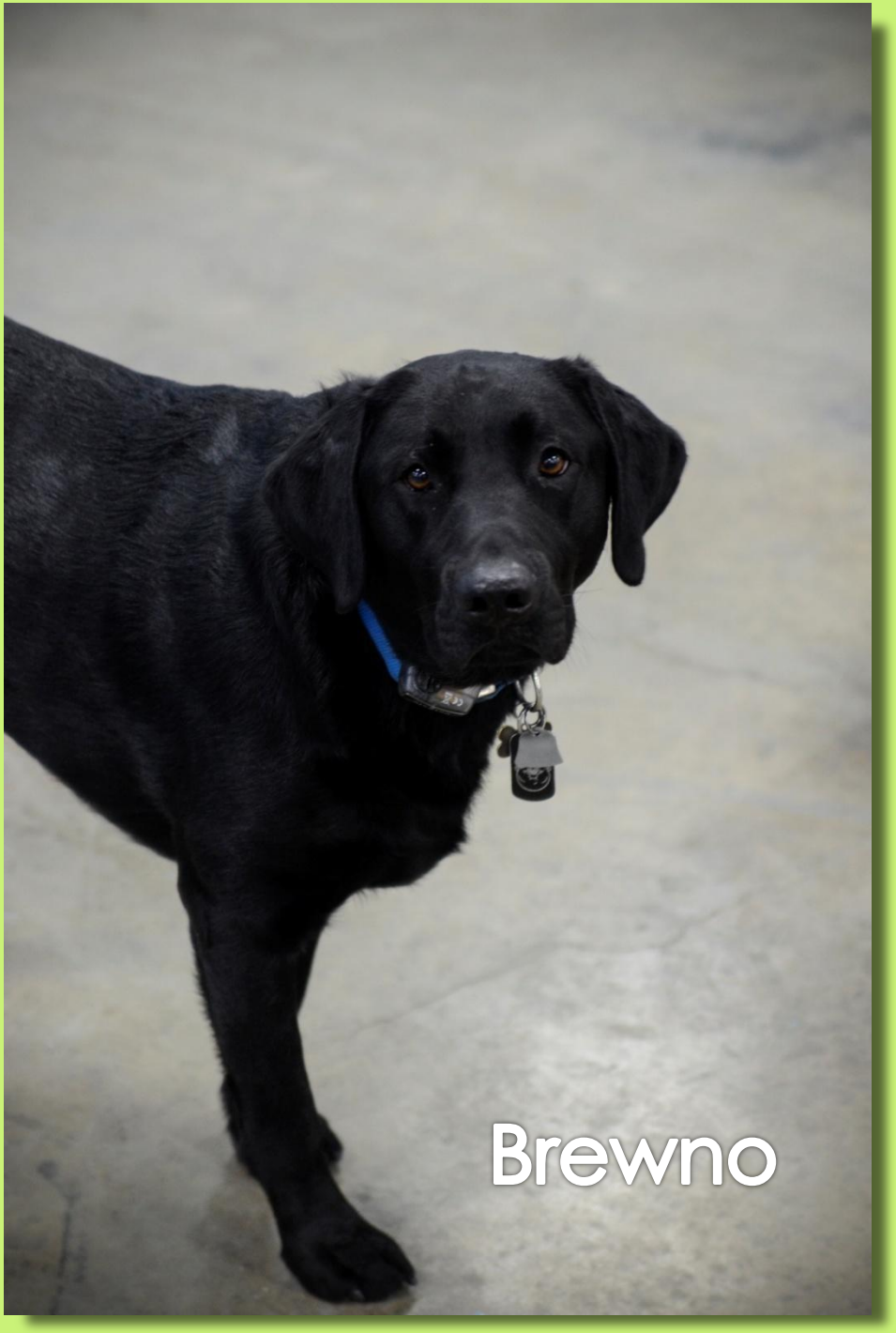
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