German Brewing Techniques

American Homebrewers Assoc.
2008 Conference

steveholle@aol.com
Overview of Today’s Presentation

• Topics
  – Overview of the Reinheitsgebot
  – Overview of common brewing methods
  – Examples of some commercial beer recipes

• Information Sources
  – Text Books – Kunze, Narziss,
  – Interviews with German brewers
  – Tours of German Breweries
Germans Brewers vs American Brewers

<table>
<thead>
<tr>
<th>German</th>
<th>American</th>
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<tbody>
<tr>
<td>Tradition</td>
<td>Innovation</td>
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<tr>
<td>Balance</td>
<td>Extreme Flavors</td>
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<tr>
<td>Freshness</td>
<td>Variety</td>
</tr>
<tr>
<td>Science</td>
<td>Art</td>
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Reinheitsgebot or Purity Law

• Written in 1516 (oldest food law still in force)

• 1516 Law is not the same as provisions defining Purity Law in Biersteuergesetz ("beer tax law")

• 1516 Law does not include the modern requirements for labeling a beer as “brewed according to the Reinheitsgebot”

• Modern innovations have required ongoing interpretation about what is permissible
German Reinheitsgebot applies to

- All beer brewed in Germany and sold in Germany
- All beer brewed in Bavaria and Baden Württemberg and sold in or outside Germany
Exceptions to Reinheitsgebot

- Beers brewed outside Germany and imported (EU ruled in 1987 law was restraint of trade between EU members)
- Beer brewed in Germany and exported (except Bavaria and Baden Württemberg)
- Malt beverages not labeled as “beer”
- Beer cocktails mixed in taverns – Examples: Berliner Weisse, Russ’n, Radler
- Experimental beer
- Homebrew
“Radler” is a mixed beer drink of 50% Helles Bier and 50% Sprite/7UP. The Brits call this a “Shandy”. It is usually mixed at the bar; however, Warsteiner is selling this concoction in a beer bottle, but the bottle is labeled “Mischbiergetraenk” and not “Beer”. Therefore, the Reinheitsgebot does not apply.
Malt

- Malt only, no adjuncts (loophole: Spitzmalz)
- Lager beer can only use barley malt
- Ales may use any malted grain (wheat, rye, spelt)
- Malt must be milled on site (i.e., no malt extract)
- No coloring (loophole: Farbebier, aka “colored beer”)
Water Treatment
Kloster Brauerei Ettal, Ettal
Water

• Normal public water treatment allowed by “Trinkwasserverordnung”: chlorine, ozone, UV

• Treatments allowed: filtration, reverse osmosis, ion exchange, slaked lime

• Salts permitted: Gypsum and CaCl, if added to water only

• Cleaning and disinfectantsolutions allowed
  — with assumption that they are rinsed
Acidification

• Prohibited
  • Addition of industrially/non-biologically produced acid

• Permitted
  • Acid rest
    • mash in at 45°C and let mash stand overnight – no longer commercially practiced (too slow, too variable)
  • Sauermalz
    • Regular pilsner malt sprayed with Sauergut
  • Sauergut, aka, sour wort
    • Wort is inoculated with cultured lactic bacteria or from wort that has been subjected to an acid rest
Sour Wort
via lactic bacteria (Sauergut)
Wochinger Braeu, Woching
Hops

- Pellets allowed
- Extracts allowed if derived by natural solvents like ethanol, CO2
- Isomerized extracts not allowed
- Hops allowed in kettle only (i.e., no dry hopping)
Yeast

• No nutrients or additives
  • Oops! Is that a zinc pipe
  • Macerated and heat deactivated yeast

• No acid washing

• Lager yeast in wheat beer bottle conditioning permitted (barley kräusen can’t exceed 15%/v)

• Brewers not as focused on strain of yeast
  – Strain 34/70 = WY2206 & WLP830
Yeast Transfer Tub
Brauerei Greifenklau, Bamberg
Mashing Regimes

• Single temperature infusion
  • Almost unheard of in Germany
  • For a Braumeister, much too simple to make good beer

• Decoction – losing popularity due to time & $$
  • dark beers – caramel & phenols (fuller, rounder flavor)
  • wheat beers – denature proteins to improve viscosity
  • small traditional breweries
  • Increase fermentability

• Step infusion mash – most common
• Endosperm mashing – Trumer
German Mashing Regimes Require Sophisticated Equipment

• Mash agitator
  • Mixing during step infusion
  • Mixing for decoction

• Lauter tun rakes
  • Decoction and pumping dearates mash so it won't “float“ as in British-style single temperature infusion

• Mash pump
Mash Tun
note the 2 agitator arms and copper chain to prevent scorching
# Classic Mash Temperatures

<table>
<thead>
<tr>
<th>Temp</th>
<th>Purpose</th>
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<tbody>
<tr>
<td>35°C</td>
<td>(optional) starting point for mash in, especially triple decoction</td>
</tr>
<tr>
<td>45°C</td>
<td>(optional) degrade β-glucans &amp; produce ferulic acid _ 4 VG in Weissbier</td>
</tr>
<tr>
<td>50°C</td>
<td>protein rest &amp; degrade β-glucans</td>
</tr>
<tr>
<td>62°C</td>
<td>gelatinization/liquefaction (beta amylase)</td>
</tr>
<tr>
<td>72°C</td>
<td>saccharification (alpha amylase)</td>
</tr>
<tr>
<td>78°C</td>
<td>mash off</td>
</tr>
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</table>
Water:Grist Ratios

(wt/wt, 1 liter = 1 kg, 1 qt = 2 lb)

- Mash more liquid than English infusion mashes because German mashes are stirred and pumped.
- Water grist ratios are adjusted for beer type:
  - 3.0 to 3.5 : 1 for dark and/or malty beers (Maerzen)
  - 4.0 to 5 : 1 for pale and delicate beers (Pils)
- Lower water : grist ratio requires more sparging: _efficiency_ _phenols_ _fermentability_
- Higher water : grist ratio requires less sparging: _efficiency_ _phenols_ _fermentability_
Lautering

- Continuous sparging is probably more common in larger breweries
- Batch sparging with 2 or 3 sparge water additions (“Nachgüsse”)
- Less common to heat kettle intensely while filling
  - convert starch to dextrins @ 75°C, start heating at kettle full
  - Consistent flavor and stability from consistent boiling parameters, i.e. time and temperature
Lauter Tun
Brauerei Greifenklau, Bamberg
Hops

• 1 to 4 additions depending on style
• Aroma hops are usually boiled 5 to 10 minutes to remove grassy flavors
• No dry hopping, but hops are sometimes added right before whirlpool, but not in whirlpool
• No bittering or hop oil extract can be added after kettle
Knockout

• Aerate in-line between chiller and fermenter with sterile air (not oxygen)
• Knockout colder than fermentation temp.
• Flotation tanks for lagers when fermented in flat bottom fermenters
  • Can’t remove trub in flat bottom fermenter
  • Can’t harvest yeast if flat bottom filled with trub
Coolship at Bavarian Farm Brewery
Top Fermentation (ales)

• Open fermenters still common for Weissbier, brewpubs, and traditional Bavarian lager breweries
  • Skim and remove trub first +/- 2 days
  • Then harvest yeast by skimming
• Pitching rates
  • Weizen - 5 to 10MM cells/ml
    • Yeast cells double more times at warm temps
    • Yeast growth promotes higher ester production
  • Perhaps higher rate for cool fermented Alt and Koelsch due to colder temp and lower ester profile
Weissbier Fermenter
Schneider
Open Brewpub Fermenters
Fliegerbraeu, Munich
Bottom Fermentation (lager)

- Pitch 15 to 30MM cells/ml
- Knockout colder than fermentation temperature @ 6 to 8°C
  - Oxygen solubility _
  - Protection against invading microbes
  - Reduces fruity/spicy higher alcohols and esters
- Free rise to 9 to 10°C, achieve about 80 - 90% of attenuation limit in 1 week
- Drop to lagering temperature (0 to 2°C) by 1°C/day (DON’T CRASH!!!!!!)
- Condition for 3 or more weeks (diacetyl rest sometimes used by larger brewers up to 20°C)
- Tank is bunged and remaining extract (1 – 2% remaining fermentable extract) or added kraeusen (10%) carbonates beer
Open Lager Fermenter
(Kloster Brauerei Ettal, Ettal)
Open Lager Fermenter
(Kloster Brauerei Ettal, Ettal)
Open Lager Tank
Brauerei Greifenklau, Bamberg
Clarification/Filtration

• Not Permitted — these are not inert, can’t be fully removed
  • Irish moss
  • Isinglass
  • Forced carbonation from CO₂, if not produced by fermentation

• Permitted — inert ingredients that can be removed by filtration or sedimentation
  • PVPP (plastic flakes that adsorb tannin)
  • Silica gel
  • DE and cellulose filters
  • Carbonation by spunding (bunging) and kräusen
  • Forced carbonation from CO₂ captured from fermentation
    OK
Spundapparat
pressure-relief valve for carbonation
German Brewers Are Very Mindful of pH throughout entire process

- 5.4 to 5.6 pH in the mash
- 5.1 to 5.4 at end of boil
- 4.2 to 4.4 at end of fermentation (4.6 bacteria active and taste affected)
- Focus on the beer pH, not the mash!!!!!!
- Homebrew pH is often too high!
German Lagers may have higher levels of SO2 (sulfur dioxide) than American lagers

- SO$_2$ should not to be confused with:
  - DMS – inadequate boil (should never be found in German lager)
  - H$_2$SO – stressed yeast / unwanted microbes
- Lager yeast naturally produce more SO$_2$ than ale
  - German brewing techniques produce/trap more SO$_2$
  - Cold fermentation, cold lagering
  - Natural carbonation (forced carbonation scrubs SO2)
Factors contributing to increased SO2  
Dr. Greg Casey, Coors Brewing

- Lager yeast strain produces more S02 than ale
- Spunding and kraeusen (trapped CO₂)
- Sulfates in water
- Cold temperature (Miller – beer fermented at 10°C 2x more SO₂ than at 15°C)
- Suntory of Japan noted more SO₂ with all malt beers than with adjunct beers
Factors contributing to decreased SO2

- Ale yeast
- Pasteurization
- Higher beer storage temps
- Increased tank venting
- CO$_2$ release purges SO$_4$ from beer
- Fast fermentations
- Non-pressurized fermentation/conditioning
Beer from the Lager Tank
Taste the freshness and SO2
Paulaner Braeuhaus, Munich
Appendix

• Typical Grain Bills – a lot of a little

• Actual German Brewery Recipes
  • Munich Dunkel
  • Weizen
    • Hell
    • Dunkel
    • Helles
  • Pils
  • Koelsch
  • Alt
Malt Color

- Use a lot of low color malt instead of a little of a high color malt
  - 100% vienna or munich malt can be used
  - Cara malts are usually less than 5% of grain bill
  - Dark/Roasted malts are usually less than 1%

- Roasty flavor rarely acceptable, except a hint in Schwarzbier. Ways to add color, but no roast flavor
  - Farbebier (colored beer)
  - Dehusked roasted malt (carafa)
# Malt Bill for Various Beers

(Source: Narziss, Brauwelt, 6, (1990), p. 178-184.)

<table>
<thead>
<tr>
<th>Beer Type</th>
<th>Malt Type</th>
<th>Malt EBC</th>
<th>% of Grist</th>
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<td>Pils</td>
<td>pilsner</td>
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(Continued)

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Malt Bill for Various Beers
(Continued)

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<td>Alt</td>
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<tr>
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<td>melanoidin</td>
<td>35</td>
<td>50</td>
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Malt Bill for Various Beers

Notes:

• **Black Dark malt is called Farbemalz (colored malt)**

• **Black malt has color of 1300 to 2500 EBC**

• **Melonoidin malt is also known as Bruhmalz**

• **Munich malt is also know as Dunkles Malz**
German Bier Recipes

- Recipes from commercially brewed beers
- Note not only the grain, hops, and yeast, but also the process variables.
Monastery Weltenburg – Munich Dunkel
2008 World Beer Cup Gold Medal

Malt: 75% Munich, 20% pale, 5% specialty (caramel and roasted)
Water: Grist Ratio: 3 to 1
Mash (2 decoctions)  
- Mash in @ 52°C, rest 10 min
- Pull 1st decoction (30%) & boil 20 min
- Rest @ 63°C, rest 30 min
- Pull decoction & boil 20 min
- Mash off @ 74°C

Lautering  
- Vorlauf – 5 to 10 min
- First wort runs off in 1:15 hr
- 3 sparge water additions @76°C
- Total lautering time = 2.5 to 3.0 hr

Boil  
- 50 min @ 103°C (external calandria)

Hops  
- 3 additions: 1st @ boil start; 2nd after 25 min; 3rd at end
- IBU - ??
- (Probably Hallertau/Hallertau and/or Hallertau/Perle)

Whirlpool  
- 20 min stand

Knockout  
- 12.5°P @ 6°C w/ 2 stage counter flow wort chiller

Aeration  
- 6 mg of O₂ and pitch proprietary yeast @ 30MM cells/ml

Flotation  
- 2 hours

Primary  
- 7 days @ 9°C in flat-bottom enclosed fermenter – fully attenuated

Conditioning  
- 3 to 4 weeks @1°C w/kraeusen for natural carbonation

Filtration  
- DE
Export Dunkel
(small Bavarian brewer)

OG 12.8˚P
BU na
Water no treatment, except water salts and sauergut
Malt 94% Munich malt, 6% caradunkel, 0.1% Farbemalz (black); Farbepier in kettle
Mashing (1 decoction)

<table>
<thead>
<tr>
<th>Temperature (˚C)</th>
<th>Rest (min)</th>
<th>Comment</th>
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</thead>
<tbody>
<tr>
<td>50</td>
<td>-</td>
<td>Mash in</td>
</tr>
<tr>
<td>64</td>
<td>10</td>
<td>Pull decoction to raise mash to next rest; boil 20 min</td>
</tr>
<tr>
<td>72</td>
<td>20</td>
<td>Saccharification rest</td>
</tr>
<tr>
<td>75</td>
<td>--</td>
<td>Mash off/Transfer to lauter tun</td>
</tr>
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</table>

Lautering 2:20 hr total; 1:00 first runnings, 1:20 for 2 sparge additions
Boil 1:45 hr

Hops

<table>
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<tr>
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<th>1&lt;sup&gt;st&lt;/sup&gt;</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt;</th>
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<tbody>
<tr>
<td></td>
<td>45% Hallertau Perle 10 min after boil start</td>
<td>55% Hallertau Perle 30 min after boil start</td>
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Ferment Cool to 7˚C in 65 min
Schneider Weisse Original
Kelheim

Malt: 60% wheat malt, 40% pale barley malt (color comes from <1% carafa)
Water: Grist Ratio: 5.5 to 1 (very liquid)
Mash (2 decoctions) 35°C, mash in
44°C, 10-15 min (ferulic acid _ 4VG)
52°C, protein rest
62°C, gelatinize
72°C, saccharification
Mash off
Lautering 3.5 hr
Boil 58 min @ ??°C with external calandria
Hops 12 IBU
Whirlpool
Knockout 12.8°P @ 16°C
Aeration 5 mg of O₂ in-line
Yeast proprietary yeast @ 4-7MM cells/ml (don’t reuse yeast – top crop)
Primary ? Days @ 16-24°C in open fermenters – fully attenuated
Bottle Conditioning centrifuge to drop yeast count to 0.3 to 0.5MM cells/ml
cool beer to 2.5g CO₂/L (8°C)
Mix Speise in tank for 6.5g CO₂/L (3.2 CO₂ v/v)
Fob bottles after filling
1 week @ 20°C, then 2 week @ 10°C
Observations by Hans Peter Drexler (Schneider) on Weissbier

- Longer the rest at 44°C, the higher the 4-V-G (clove phenol)
- Low Kolbach index (38%) for wheat and barley needed for estery beer
- Removal of cold break creates neutral taste and is not necessary
- Open fermenters increase esters
- Bottle conditioning increases phenols
- $O_2$ reduction at bottling important
Hefeweizen Beer
Doemens Akademie

OG 12 to 13˚P
BU 13
ADF 80%
CO2 6g/L
Malt 60% Wheat, 38% Pale barley, 2% Sauermalz
Water: Grist 3.75:1

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Rest</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>20</td>
<td>Precursor ferulic acid for 4VG formed</td>
</tr>
<tr>
<td>50</td>
<td>10</td>
<td>by direct heat to mash tun</td>
</tr>
<tr>
<td>62</td>
<td>10</td>
<td>After 10 min. pull 1st decoction decoction in 10 min raise to 72˚C, hold 15 min, then boiling for 15 min</td>
</tr>
<tr>
<td>72</td>
<td>15</td>
<td>Add decoction to raise main mash to 72˚C</td>
</tr>
<tr>
<td>78</td>
<td>--</td>
<td>Transfer to lauter tun</td>
</tr>
</tbody>
</table>

Hops Hallertau Perle pellets, one addition 10 min after start of boil
Ferment at 20˚C until fully attenuated,
Bottling add Speise held back from brew day, and condition at room temperature
Hefeweizen
(small Bavarian brewer)

OG 12.4%
BU na
H₂O treatment none
Malt to
- 56% wheat, 28% pale barley, 12% Munich, 4% Caradunkel; Farbeier equal 1.5% added to kettle
Mashing (1 decoction)

<table>
<thead>
<tr>
<th>Temperature (˚C)</th>
<th>Rest (min)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>15</td>
<td>Mash in</td>
</tr>
<tr>
<td>52</td>
<td>5</td>
<td>Optional, may begin heating immediately to next rest</td>
</tr>
<tr>
<td>62</td>
<td>20</td>
<td>Pull decoction, boil 20 min, add back for next rest</td>
</tr>
<tr>
<td>72</td>
<td>72</td>
<td>Optional, add decoction to raise main mash to 72˚C</td>
</tr>
<tr>
<td>75</td>
<td>--</td>
<td>Transfer to lauter tun</td>
</tr>
</tbody>
</table>

Lautering 2:20 hr total; 1:00 first runnings, 1:20 for 2 sparge additions
Boil 1:45 hr
Hops 1 addition of Hallertau Perle 10 min after boil start
Ferment Cool to 16-17˚C in 65 min.
Export Hell
(small Bavarian brewer)

OG 12.3˚P
BU na
H₂O treatment sour wort - 1% of knockout volume added at mash in, 0.5% added in kettle
Salts CaCl
Malt 96% pale barley, 2% carahell, 2% caradunkel
Water: Grist na
Mashing (1 decoction)

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<tr>
<th>Temperature (˚C)</th>
<th>Rest (min)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>58</td>
<td>15</td>
<td>Mash in</td>
</tr>
<tr>
<td>64</td>
<td>20</td>
<td>Pull decoction to raise mash to next rest; boil 10 min</td>
</tr>
<tr>
<td>72</td>
<td>25</td>
<td>After 10 min. pull 1&lt;sup&gt;st&lt;/sup&gt; decoction</td>
</tr>
<tr>
<td>75</td>
<td>--</td>
<td>Transfer to lauter tun</td>
</tr>
</tbody>
</table>

Lautering 2:20 hr total; 1:00 first runnings, 1:20 for 2 sparge additions
Boil 1:30 hr
Hops 1<sup>st</sup> 30% Hallertau Perle 10 min after boil start
   2<sup>nd</sup> 30% Hallertau Perle 30 min after boil start
   3<sup>rd</sup> 20% Tettnang 60 min after boil start
   4<sup>th</sup> 20% at knockout
Ferment Cool to 7˚C in 65 min.
Schoenramer Pils
Brauerei Schoenram, Schoenram, Bavaria

- soft water, **low alkalinity**, chloride and sulfate ions enhances body and aroma respectively
- very pale barley variety with a lot of enzyme activity (we use the variety Barke, the palest available)
- intense mash, single-decoction best as it **boosts attenuation**. Rests vary according to year, but a long time around 65°C is necessary
- high attenuation (>87% apparent) enhances hop character (dryness) and at the same time, through the higher level of alcohol, **adds a sweetness** to balance out the bitterness
- I am a proponent of aroma hop varieties and **use only aroma varieties** for my Pils (as for all my beers), even for the bittering - 4 different varieties given 5 times, more than 50% as late hopping, all are Bavarian hop varieties from the Hallertau and Spalt (the varieties and combination a secret I'm not at liberty to give away)
- enough evaporation to drive out DMS ( > 5.5% )
- acidification of mash and wort to adjust pH (**lactic acid derived from the malt and propagated to around 1.5%**)
- hot trub separation with the whirlpool, **cold trub separation with flotation tank**
- fermentation in open vessels beginning around 7°C, max. temperature 9°C, pitching rate 18 million cells per ml (about 1 liter of thick yeast per hl)
- ferment close to final attenuation, cool to 3°C over 2 days (total fermentation time with cooling around 8 days) add 8% kraeusen beer when transferring to lagering
- **we skim our fermentation head almost daily**
- hold in tank at 3°C for 2 weeks until vigorous secondary fermentation begins to calm down, **gradually cool** to below 0°C (around minus one) over two weeks
- last two weeks below freezing, total lagering 6 weeks, 5 weeks is also OK, but not less
- ensure minimal oxygen take-up at bottling
Prost!