Former brewhouses and their evolution to modern brewing systems

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Changing from an „old“ brewhouse to a modern one

- Advantages:
  - Shorter processtime
  - Automation
  - Less energy
  - Better yield (?)
  - Better flavour stability of beer

- Complaints:
  - Loss of foam
  - Change of taste (less body, harsher)
  - Problems in fermentation (Zinc)

- Counteractions, demonstrated by foam as an example

Comparison of former and new brewhouses

	Former brewhouses (till 1960)	New brewhouses (since 1980)
Material	Copper, black steel	Stainless steel
Mashing	Stirrers: only 2-3 steps, shear, air uptake during mashing-in and from vessel to vessel oxygen content of water 3-8 ppm	Stirrers step-less transfer to bottom, no air uptake N-cushion possible, de-aerated water
Lautertun	Mash transfer from top, air uptake, particles under false bottom, circulation, transfer time 20-25 min, rest 15-30 min „open“ lautering, time: first wort 90-120 min, sparges too	Mash-transfer via bottom 5-8, 5-0 min rest, first wort 30-40 min sparges 60-70 min de-aerated water
Mashfilter	Mash transfer from top, open lautering oxygen content of sparges up to 10 ppm!	Fine grist (oxidation??) milling under CO_2 or N_2 filling from bottom, N_2/CO_2 pre-filling water de-aerated
Holding vessel	Wort inlet from top, air threads…	Wort inlet from bottom…
Wort boiling	Inlet from top, boiling with open doors 105-150 min, evaporation 4-8%/h	Wort inlet from bottom, closed system (energy recovery) boiling time 60 min ± temperature of heating medium?
Wort treatment	Coolship (quick pre-cooling to 80°C) sedimentation tank, early whirlpool trub separation? Longer cooling time thermal load	Whirlpool h:d=1:3, transfer 6-7 min big cooler, time: end of boil-end of cooling below 90 min. Vacuum, pre-cooling?

The effect of „air-free“ mashing

- **Less oxidation of proteins, less gel proteins, less dough, better degradtion of**
  - Starch – higher final attenuation
  - Proteins – higher soluble N, more FAN, less HMW peptides
  - β-Glucan – slightly better degradation

Table 1.

- **Less oxidation (oxidases cannot fully react)**
  - More polyphenols – stronger protein-precipitation (boiling)
  - Lipoxygenase also curbed, less precursors of carbonyls
  - But less foam
  - Lower wort and beer colours

- **Measure taken**
  - Malts: limited proteolysis
  - Higher mashing-in temperatures
  - Shorter rests – save at 70-72°C (glycoproteins)
  - Deviation from optimal temperatures
  - Biologicsal acidification - pH mash: 5,5
    - pH wort: 5,1
  - Decoction mashes: inactivation of oxidases
    inactivation of proteases
  - Wort boiling – lower intensity

Table 2.

Table 3., 4., 5., 6., 7., 8.

- **Improvement of flavour stability**

Table 1. Influence of the material of vessels (copper, glass) on same components of beer (Bauer 1980)

Material	Copper	Glass
Polyphenols mg/l	222	259
Anthocyanogens mg/l	76	104
P. I.	2,95	2,49
Tannoids mg PVP/l	48	99
Total-N mg/100 ml	80,1	85,6
Coag.-N mg/100 ml	1,8	2,3
Colour EBC	8,9	8,1

Table 2. Rest during mashing and foam/ protein-fractions

Normal mashing: 50°C/45 min, 65°C/45 min, 70°C/45 min, 75°C
Tests: 50°C/90 min, 50/55°C/90 min, 65°C/90 min, 70°C/90 min

Procedure	N	50°C 90 min	50/55°C 45/45 min	65°C 90 min	70°C 90 min
Beer foam R&C	133	128	128	126	136
Total-N mg/100 ml 12% P	68,9	78,2	79,5	71,3	70,9
$MgSO_4$ in % Total-N	26,8	25,1	25,2	26,8	25,4
Fraction 10-60 KD	7,4	6,9	7,1	6,6	8,2
In % Total-N	10,2	8,8	8,9	9,3	11,6
Glycoproteins	0,55	0,51	0,48	0,49	0,64

Quelle: www.tum.wzw.bgt.de

Table 3. Influence of air/oxygen -reduction during mashing/lautering

Mashing	**From top**	**From bottom**	**Reduced rests**
Lauter time	168	152	150
Wort analysis Iodine reaction ΔE	0,35	0,20	0,23
Final attenuation %	81,3	82,4	81,8
Total N mg/100 ml	105	112	102
$MgSO_4$-N in % T-N	21,0	17,9	21,3
FAN mg/100 ml	22,0	24,3	22,0
Polyphenols mg/l	187	210	200
Anthocyanogens mg/l	78	100	98
Tannoids mg/l	75	90	90
Viscosity MPAS	1,84	1,78	1,83
Colour EBC	12,0	10,0	9,7
Beer analysis			
Colour EBC	9,2	7,3	7,0
Foam R&C	128	124	128
Stability ACT EBC	12	10	10
Warm days 0/40/0°C	2,2	1,8	2,0
Taste DLG (1 worst – 5 best)	4,2	4,3	4,4
Flavour-Stability (1 best)	2,0	1,4	1,3

Table 4. Air-free mashing (N_2-gas „cushion“)
- beer foam, protein-fractions
- pilot-plant (60 l)

Brew **O2-uptake (Lie) ppm**	**Normal** **105**	**N2** **0**
Mashing-in temp °C pH	50 5,75	50 5,75
Beer foam R&C	136	130
Total-N mg/100 ml 12°P	84,6	87,9
$MgSO_4$ in % Total-N	21,7	21,0
COOM. in % Total-N	28,8	27,0
FPLC-Hydrophobicity	20,8	19,3
SDS-Electrophoresis 14 KD	82,3	76,1

Table 5. Air-free mashing, limited malt modification - biological acidification

Brew **Germination days**	**Normal** **7**	**6**	**N2** **7**	**6**
Mashing-in temp °C		50		
pH			Mash 5,4/Wort 5,0	
Beer foam R&C	131	133	132	134
Total-N mg/100 ml 12°P	85,7	81,9	83,2	85,7
$MgSO_4$ in % Total-N	20,0	20,1	21,6	23,7
COOM. in % Total-N	28,0	29,5	28,2	30,8
FPLC-Hydrophobicity	23,9	28,5	16,9	15,4
SDS-Electrophoresis 14 KD	83,1	86,5	80,8	87,1

Table 6. Air-free mashing, limited malt modification, biological acidification, higher mashing-in at 60°C on beer foam and protein-fractions

Mashing-in °C **Germination days** **pH mash/wort**	**50** **6** **5,4/5,0**	**60** **6** **5,4/5,0**
Beer foam R&C	134	137
Total-N mg/100 ml 12°P	85,7	83,2
$MgSO_4$ in % Total-N	23,7	23,0
COOM. in % Total-N	30,8	38,5
FPLC-Hydrophobicity	15,4	18,8
SDS-Electrophoresis 14 KD	87,1	88,1

Quelle: www.wikipedia.org

Wort boiling

- Change of systems: from „dimple copper“ to internal and external heating-systems
- Promoted by energy crisis 1973, 1977, 1980
  - reduction of evaporation from 12-15% to 4-5%
  - by low pressure wort boiling 106°C
  - high temperature boiling ~ 130°C
- But anyway: even with the „old“ coppers foam deterioration, due to the factors mentioned

How to reduce excessive loss of foam + substances?

- Internal/external boilers
  - faster reactions by higher temperatures, thus more precipitations…..
- Temperature in the heater 106 103°C
  - important temperature of heating media
  - size, heating surface… instead of 150°C (super heated)
  - down to << 120°C(saturated steam) 107°C – vapour re-compression
  - large evaporation surfaces/screen (double)
- Homogeneity of boiling external heater
  internal heater (driving pump), subject to
- Shorter times, „rests“ = 20`B, 20`R, 20`B; or shorter times ca. 40 min but anciliary equipment vacuum treatment, precooling to whirlpool

Table 7. Parameters of wort boiling and beer foam/ External heater

Wort temperature in the heater °C	106	104	104
Boiling time min	70	60	60
Temp. heating media °C	150	135	117*
Evaporation rate %	11	8,5	8,5
Wort analyses			
Colour EBC	9,4	9,0	8,7
Total-N mg/100 ml 12°P	107	108	109
Coag-N mg/100 ml 12°P	1,2	1,6	1,8
High mol.-N mg/100 ml 12°P	20,3	21,3	22,7
EBC-BU	30	29	28
Beer analyses			
Colour EBC	6,7	6,5	6,2
Total-N	80	80,5	80,8
Coag-N	1,0	1,35	1,65
High Mol.-N	15,7	16,3	17,2
Beer foam R&C	122	124	127
EBC-BU	21,5	21,1	20,7
Taste test			
∅ DLG	4,0	4,2	4,4
Bitterness	4,0	4,1	4,2

*** vapour compression**

Table 8. Wort boiling, varied processes, wort characteristics and beer foam (flavour stability)

	Start Boiling	End Boiling	Cold Wort	Foam	DLG* Aged
Internal heater 80 min					
Strecker aldehydes	520	130	280		
Furfural	70	170	260		
Lipid-Derivatives	210	12	7		
DMS-P/ Free	550/10	80/20	40/50		
Coag.-N mg/l	50	20	18		
TBF	27	44	55	120	3,4
Internal heater 60 min wort precooling 88°C					
Strecker aldehydes	520	170	185		
Furfural	70	160	185		
Lipid-Derivatives	210	25	20		
DMS-P/ Free	550/10	120/20	110/30		
Coag.-N mg/l	50	25	23		
TBF	27	39	44	125	3,9
Internal heater 60 min vacuum step after whirlpool 80°C					
Strecker aldehydes	520	170	200		
Furfural	70	160	195		
Lipid-Derivatives	210	25	4		
DMS-P/ Free	550/10	120/20	60/20		
Coag.-N mg/l	50	25	23		
TBF	27	39	47	125	4,0

(*1 worst 5 best)

Table 9. Flavour stability and technological factors

Mashing Procedure	50/77/77°C	62/70/77°C	50/70/77°C	62/70/77°C
	Fresh		Forced	
Σ Ageing components (ppb)	43	37	145	109
Forcing-Index	42	35	98	66
Ageing-Index	58	61	124	91

Atmosphere (forced ageing)	N2	Normal
Σ Heat indicators (ppb)	82	107
Σ Oxygen indicators	49	52
Σ Ageing components	135	167
Forcing-Index	96	104
Ageing-Index	119	130

pH (forced ageing)	5,2	5,7
Σ Oxygen indicators (ppb)	27	41
Σ Ageing components	156	191
Forcing-Index	102	135
Ageing-Index	131	178

Quelle: www.brauer-bund.de

Thank you…

…for your attention

Thanks …

To my friends

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