
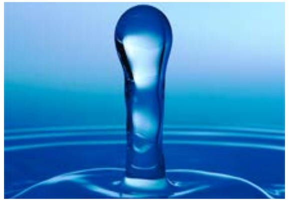
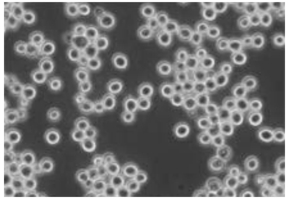

Versuchs- und Lehranstalt für Brauerei in Berlin (VLB) e.V.

Scale up/down

New possibilities to close the gap between lab, pilot brewery and industrial scale

Overview

- Challenges of scale up/down
- How is the normal process
- Our Approach - construction Nanobrewery
- Trials/optimization Nanobrewery
- Downstream process
- Scale up/down trials
- Outlook

Challenges of scale up/down

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Challenges of scale up/down

- Scaling down leads higher surface to volume ratio
  - changed mass transfer (O_2 ↑↓ CO_2↑↓ volatiles ↑)
  - changed heat transfer (cooling, heating)
- Transfer problems by thinner pipelines
- Unequal distribution
- Different flow dynamics
- Hygienic design, cleaning challenges

Challenges of scale up/down

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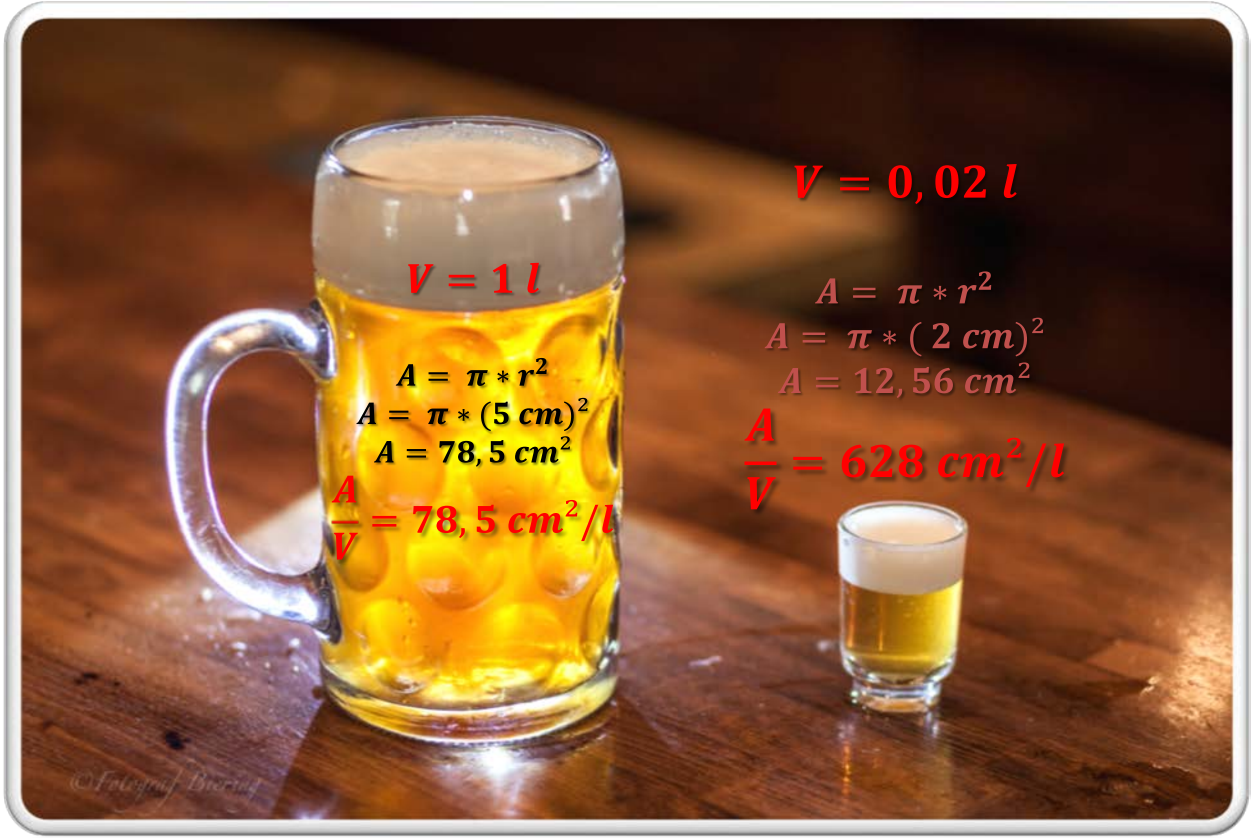

Scale up/down in brewing

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- Scale up/down step lead to:
  - Unknown oxygen uptake (mash/ wort/ beer transfer)
  - Unknown effectivity of DMS evaporation
  - Unknown hop yields
  - Risk of blockage during mash transfer, lautering, wort cooling
  - Undesired dilutions by residual water in pipes/hoses
  - Control of wort flow during lautering
- Typical steps in a ratio 1:100

Typical work flow

- Lab scale (??? ml- 5l)
  - Open vessel- Erlenmeyer flask
  - Microtiter plats
  - Untypically brewing and fermentation conditions
- Pilot scale (1hl – 10 hl)
- Industrial scale (100 hl – 1000 hl)

Our approach

Our approach

- Full automatization (minimize brewer‘s impact)
- Nitrogen gas and degassed water application (reduces oxidation)
- Heat supply and adjusted thermal load by oil bath (circulates in heating jackets)
- Regulation of the lauter flow by pressure difference
- Adjust evaporation rate by reflux condenser
- Usage of available miniplant vessels

Construction Nano-brewhouse

- Grist load: up to 1,2 kg
- Cast wort: up to 5l
- Oxygen free wort production
- Mainly made of glass
- automated

Mashtun

- Capacity: 6l
- Oxygen free mashing
- Temperature control by oil bath and heating jacket
- Measuring instruments: level, temperature

Lautertun

- Capacity: 6l
- Oxygen free lautering
- Temperature control: oil bath and heating jackets
- Measuring instruments: level, temperature, lauter turbidity
- Control of wort flow: adjusting the height of wort kettle
- Specific false bottom load: 100-150 kg/m²
- no raking machine (avoid influence on filter layer)
- Lautering without pump or control valve (avoid blocking, oxygen entry)
- Regulation by setting difference pressure

Lauter process

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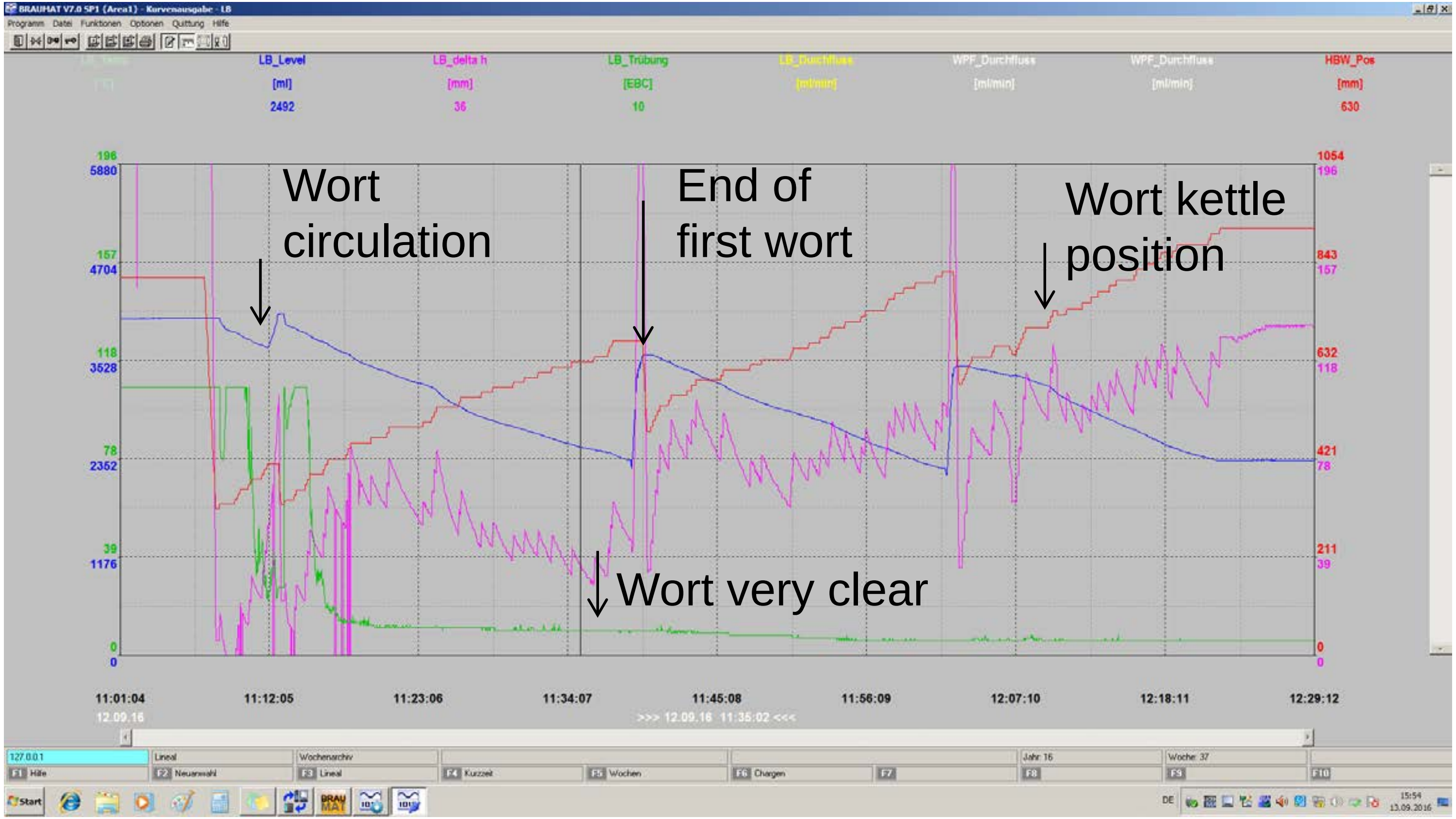


Wort kettle

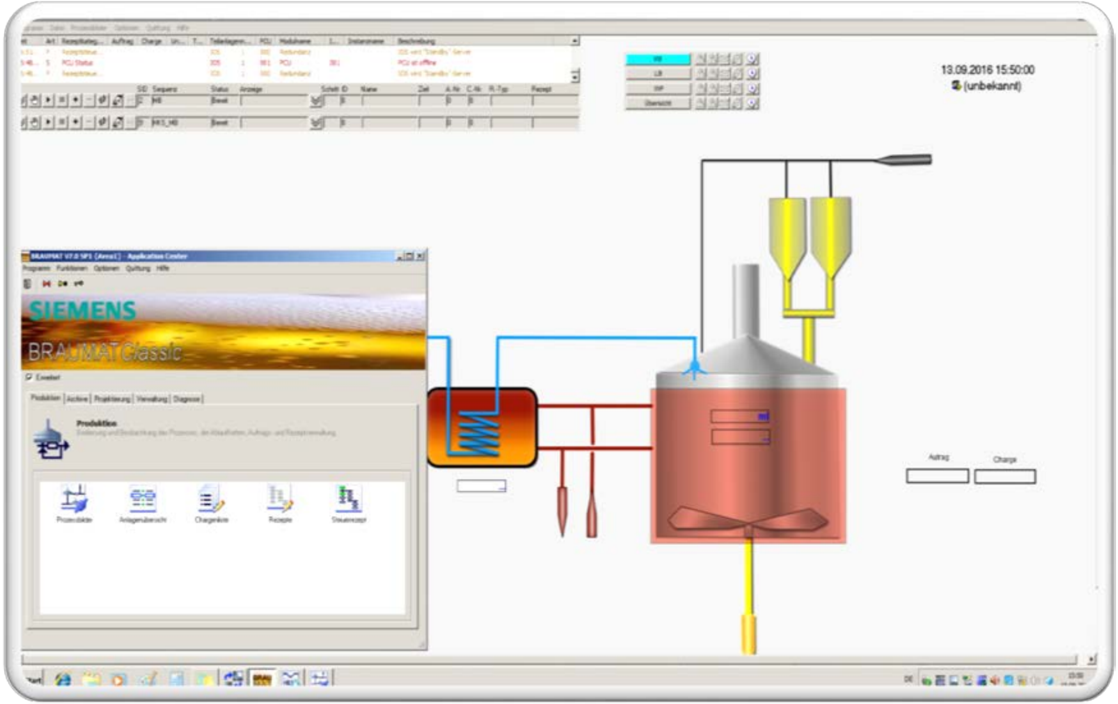
+ Capacity: 6l
+ Oxygen free wort boiling
+ Temperature control by oil bath and heating jackets
+ Measuring instruments: level, temperature
+ Possibility to reduce evaporation by reflux condenser

Whirlpool and Cooling

- Capacity: 6l
- Oxygen free
- Insulated
- Measuring instruments: temperature of cooled wort, wort turbidity
- Counterflow wort cooler

Automatization

- Braumat (Siemens)
- Visualisation of process
- Steps programmed with Step7
- Order and recipe control
- Improved Reproducibility by automatization
- Save measured data



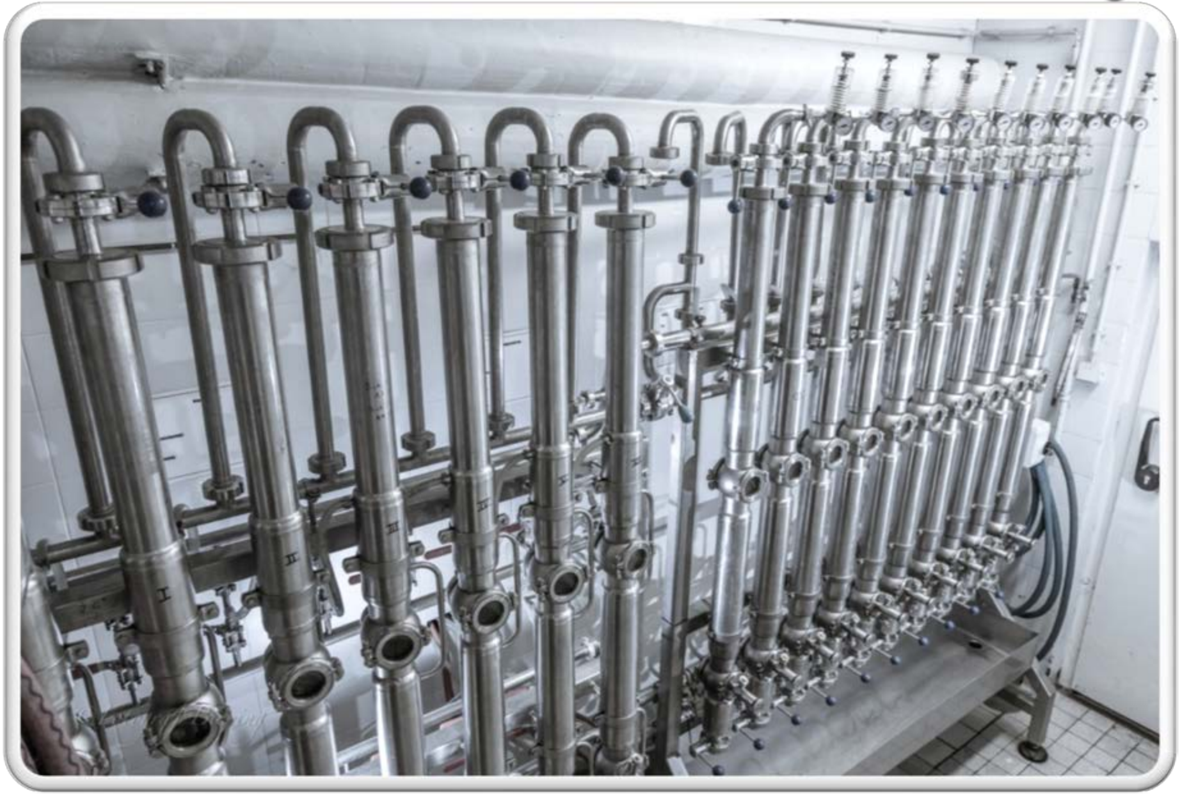
Influence of oxygen on wort colour

Wort colour [EBC] at 12% original extract	Without N_2 atmosphere	With N_2 atmosphere
Without oxygen free brewing water	18-20	14-16
With oxygen free brewing water	8-12	7,5-8,1

Lautering performance- pressure difference

Downstream process

Downstream process



Fermentation tubes- details

CIP

Sampling

Pressure Fermentation

Yeast harvest

Scale up/down trials

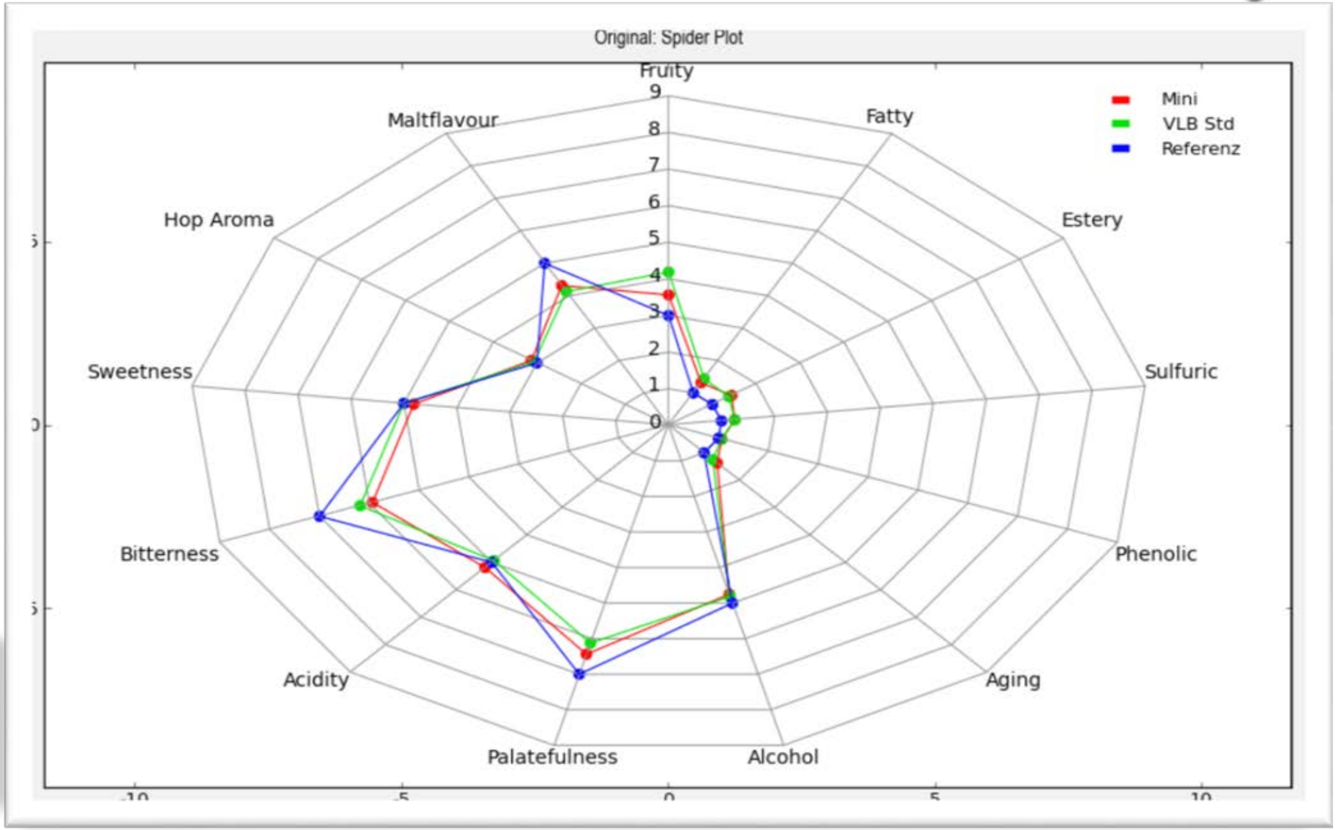
Recipe adaption

- Ratio Malt: Water → Changed
- Mash program → Slower heating up
- Mash acidification → More acid used
- Wort acidification → More acid used
- Fermentation → Different vessel

Analytical Results

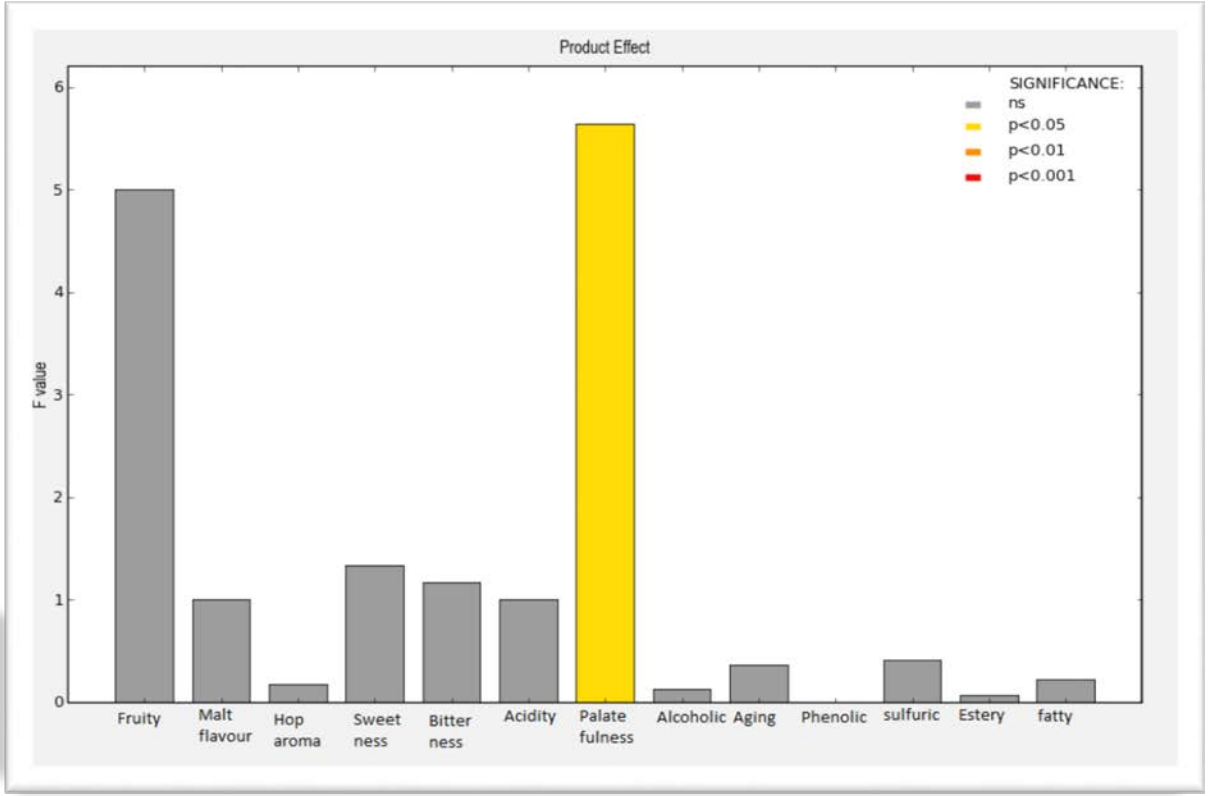
	OG [°P]	pH	Es [%GG]	Colour [EBC]	BU	ABV. [%v/v]	Free Diacetyl [mg/kg]	Total Diacetyl [mg/kg]
VLB Std	11,51	4,15	2,30	6,19	28	4,88	0,100	0,100
Minibrau	11,91	4,22	2,04	6,88	25	5,24	0,067	0,085
Difference [%]	3,48	1,69	12,75	11,15	12,00	7,38	49,25	17,65

Tasting Results



- PanelCheck: Mini vs. VLB Std. little differences

Significant differences



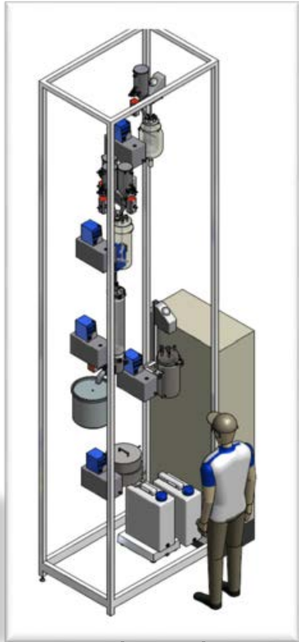
- 3 way Anova
- Significant differences:
- Palatefullness

Conclusion

+ Reproducing 2hl scale in 5l brewery succeeded
+ Adjusted recipe necessary
+ Sensory analyses can‘t detect differences below 10%?

Outlook- Nano Brewing System

Micro- Malting- 1 kg



Nano- brewhouse
5 l

Fermentation tubes
4 l

Filtration- Unit

Filling device

Thank you for your attention!

VLB Berlin

FI Bier- und Getränkeproduktion

Dr. Roland Pahl (pahl@vlb-berlin.org)

Dipl. Ing.Jan Biering (biering@vlb-berlin.org)

Dipl. Brm. Michel Werner (m.werner@vlb-berlin.org)

www.vlb-berlin.org