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MASTER BREWERS ASSOCIATION OF THE AMERICAS

HOPSTAR™ Iso

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A new GEA technology to improve hop utilization in the brewhouse

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1. Introduction

GEA Brewery Systems and Dillenburger & Hertel have developed an innovative method for the efficient use of hop extract and pellets in breweries. Based on the well-known mechanism of hop isomerization a skid was engineered and built allowing the defined isomerization of hop extract as well as hop pellets at higher process temperatures. The hops used in the brewhouse were mechanically treated in wort or water followed by a defined heating to a temperature above wort boiling temperature.

The application of higher temperature reduces the required process time for the desired transformation rate of the α-acids into iso-α-acids and leads in parallel to significantly higher isomerization rates - all process conditions can be adjusted individually. The cooling to atmospheric conditions is done in a closed system with heat exchangers to avoid a loss of valuable hop oils. Analytical results including sensory evaluation are shown and discussed. The isomerized hop should be dosed after wort boiling or preferably during wort cooling..

The controlled process and the achieved higher isomerization rates will allow a significant reduction of the amount of hop dosed to the wort thus creating a reduction on the annual hop bill as well. The process conditions will allow savings from 15 % up to 30 % of hops. This technique opens also a higher flexibility in creating new recipes and hop impressions to beer and beer-mixed beverages.

2. Target of HOPSTAR™ Iso technology: – saving of raw material cost

Driver: Losses of hop alpha acids during brewing process

Present situation:

E.g. dosing of 8 g/hL alpha acids	= 100 %
Realized yield in wort	= 66 %
Realized yield in finished beer	= 33 %

Economical result: about 2/3 of money spent for raw material hops is without generating an additional product value

Reason:
Losses caused by insolubility of alpha acids in watery solutions – alpha acids show hydrophobic structure
Losses caused by wort boiling processes not convenient in time and temperature for maximized isomerization yield

3. Project development objectives

Target:

Increasing the conversion rate when using hops as extract or pellets

Tools: controlled by the variations in certain physical parameters

Increasing the reactive surface area of the hop extract
by mechanical reduction of the droplet size
achieve an even droplet size distribution

Increasing and homogenizing the distribution of hop alpha acids in watery fluids by high speed dispersion

Increasing temperature and decreasing time for isomerization

4. Hop isomerization during wort boiling

Fig. 1: Hop cone

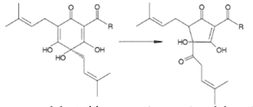


Fig. 2: Chemical structure of alpha- and iso-alpha acids

- Alpha acids
- Wort boiling
- Isomerization

⇒ valuable constituents contained in the lupulin of hops
⇒ ring changes from hexagonal to pentagonal structure
⇒ isomerized alpha acids can be solved in the wort
⇒ most important process step to create the bitterness profile in the beer
is a 1st order reaction, depending on:

- **Temperature / Reaction time / Reactive surface**

5 Mechanical treatment of hop ingredients

Dispersion and homogenization for particle size reduction

- Dispersing the hop mix with tip speed of about 21 m/s
- High speed mixer (e.g. make IKA Ultra Turrax)
- Homogenizing the hop extract droplets at 250 bar
- High pressure piston pump and homogenizing valve

Fig. 3: Dispersing unit (source: IKA Ultra Turrax)

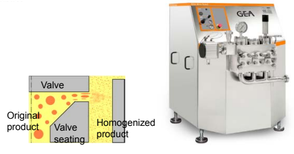


Fig. 4: Homogenizer and homogenizing valve (source: GEA Niro Soavi)

Homogenization / particle size reduction

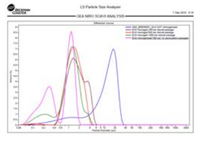


Fig. 5: Laboratory scale

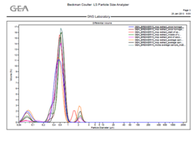


Fig. 6: Practical experience – particle size distribution

Fig. 7: Hop extract suspension

Suspension made from 35 % ethanol extract and 65 % CO_2 extract

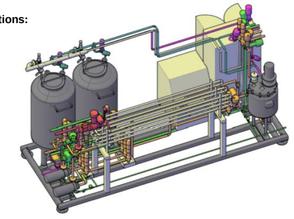
Left: dispersed – extract droplets visible
Middle: dispersed and homogenized
Right: homogenized and isomerized

6. HOPSTAR™ Iso

- **Picture: equipment with two isomerization tanks for stable and controlled isomerization process**
- **(1- or 3-tank systems available as well)**

- **Possible process conditions:**
- **About 120 – 140 °C**
- **About 15 – 20 min**

- **Isomerization rate**
- **>> 92 %**



7. Process conditions and analytical check

- **Qualitative evaluation of hop extract isomerization process by HPLC**

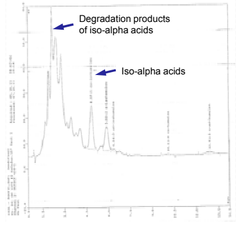


Fig. 8: False process parameters time/temperature

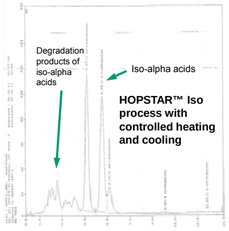


Fig. 9: Ideal process parameters time/temperature

8. Increasing yield rate

Sample (sept. - middle of cooling (moc), green beer, beer)		Simon H. Steiner, Hopfen (Hop laboratory) Bitter units (BU)	Iso-alpha acids (mg/l)	Alpha acids (mg/l)	Linalool (µg/l)
Wort moc trial Export		34.2	32.6	1.1	
Wort moc blank Export		26.7	23.7	6.4	
Yield increase, in wort		**22 %**	**27 %**		
Green beer Export		29.5	29.7	< 1	30.1
Green beer blank Export		23.1	21.7	1.9	5.3
Yield increase, in green beer		**28 %**	**37 %**		**468 %**
Bottled beer Export		24.5	24.6	1.7	26
Bottled beer blank Export		18.2	19.6	1.2	4.9
Yield increase, in bottled beer		**35 %**	**26 %**		**431 %**

Assumption for yield increase in beer: 30 %
Possible alpha acid dosage: 4.67 g/hL instead of 6.38 g/hL, reduction of 1.71 g/hL
Possible cost reduction for example:
Assumed cost of alpha acid 25. -€/kg and 1,805 brews per year:
Cost reduction for hop extract use: 77,164 €/year

Fig. 10 Export beer type

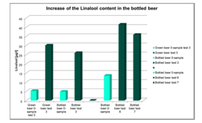
Sample (beer)	Hop dosage Alpha acid (g/hL)	Simon H. Steiner, Hopfen (Hop laboratory) Bitter units (BU)	Iso-alpha acids (mg/l)	Linalool (µg/l)
blank Pilsen:	8.96			
Trial Pilsen:	6.29			
Bottled blank Pilsen	8.96	25.9	29.0	13.6
Reduction of alpha acid dosing: 30 % less than blank				
Bottled trial Pilsen	6.29	24.9	25.3	35.9
Yield increase		**37 %**	**24 %**	**164 %**

Assumption for yield increase in beer: 30 %
Realized alpha acid dosage: 6.29 g/hL instead of 8.96 g/hL, reduction of 2.67 g/hL
Possible cost reduction for example:
Assumed cost of alpha acid 25. -€/kg and 1,805 brews per year:
Cost reduction for hop extract use: 120,619 €/year

Fig. 11: Pilsen beer type

9. Higher economic efficiency

Improved bitter acid yield by dosing of isomerized hop extract suspension
- Into the wort kettle
- Into the Whirlpool
- In front of the wort cooler
- In maturated beer before beer filtration



Improved hop flavor for specific beer types
- Significant increase in the hop oil content if wished (Linalool as indicator)

Reduction of total evaporation / lower thermal energy consumption
- By reduced boiling time or reduced evaporation rate
- Only DMSP transformation and DMS evaporation as time criterion process
- Longer boiling times for isomerization of alpha acids no longer required
- Boiling time to be limited to about 30 min with keeping of evaporation rate / target: reducing total evaporation
- Or keep boiling time with lower evaporation rate / target: reducing total evaporation (e.g. start of wort boiling, than hot holding rest followed by final boiling)

10. Calculation of profitability

Total cost savings for use of hop extract and thermal energy required for wort boiling

Isomerization process during wort boiling no longer required, this means good possibility to reduce boiling time and total evaporation by 50 %

Produced wort quantity	**2,000,000 hL/year**
• Savings of hop extract (when dosing is reduced by 30 % on the basis of 70 mg/lL alpha acid)	120,000 €/year
• Savings of energy cost * (when boiling time is reduced by 50 % and total evaporation by 50 %	134,000 €/year
• Additional energy cost for HOPSTAR™ Iso electrical energy additional heating (only 1 % of the yearly wort production volume to be heated for the isomerization process with HOPSTAR™ Iso)	- 8,000 €/year - 5,000 €/year
• **Total savings approx.**	**241,000 €/year**

- **Possible ROI in the range of 1.5 – 2 years**

- * Saved energy cost when wort boiling will be adjusted:
- (Assumptions for calculation of energy cost savings: 4 ct/kWh natural gas; total evaporation 2.2 % instead of 4.5 %; total efficiency for heat supply 90 % at wort kettle)

11. Summary

- **=> HOPSTAR™ Iso process complies in regard to raw material input and thermal energy demand for wort boiling with political request for a sustainable process**

- **Yield increase of alpha acid quantity can be between 15 % up to 30 % dependent on hop products and applied technology**
- **Significant savings of raw material cost for hops up to 30 % can be realized**

- **Regular boiling time of about 60 min is no longer necessary to isomerize alpha acids**
- **The wort boiling time can be reduced to about 30 min, evaporation of DMS can be the indicator**
- **Significant savings of about 50 % thermal energy for wort boiling can be realized**

- **Beer bitterness can be improved, even beer with high bitter units show no raspy, harsh and astringent bitterness in the aftertaste**
- **A pleasant hop flavor and smell can be realized**

12. References

- Hertel, M.: Verfahren und Vorrichtung zur Bierbereitung. EP 2 227 535 B1 vom 05.09.2012
- Hertel, M.: Verfahren und Vorrichtung zur Bierbereitung AT 507 149 B1 vom 15.02.2013
- Scheller, L.: Effiziente Aufbereitungsverfahren. Brauindustrie (2012) Nr. 10, S. 34-40