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The evaluation of hop utilisation in brewing process

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Abstract

The rate of isomerization of alpha acids to iso-alpha acids (the bittering compounds in beer) was characterized over a representative pH, wort concentration, time boiling and temperature range during the boiling portion of the brewing process.The tastes of beer typ are derivated from a judicios choise of row materials. Hops (Humulus lupulus L.), in particular, account, in adition for the bitter taste, for a delicate hoppy flavor in beer. Perhaps the most important class of hop compunds are the hops bitter acids, which are distinguished as alpha acids.. Because of the complex wort matrix and interfering interactions occurring during real wort boiling (i.e., trub formation and α-acids/iso-α-acids complexation), this investigation on α-acid isomerization was performed in wort solution as a function of time (60−120 min), pH variation (5.1-5.8) and wort original gravity (10-14oPlato).The experiments demonstrate that the rate of isomerization depending of beer matrix, the performers of wort kettle and the variety of hops.

Keywords: Beer, humulone, izohumulone, bitter units

1. Introduction

The most important class of hop compounds are the the hop bitter acids, which are distinguished as alpha-acids or humulones and beta-acids or lupulones.The two series comprise, in fact, tree constituents differing in the nature of the side chain for humulone /lupulone, cohumulone/colupulone and adhumulone/adlupulone. The relative proportion of the individual constituents depend strongly on the hop variety and the condition of growing.

The transformation of the humulones during wort boiling is a very complex chemical reaction. The most important is the thermal izomerization of the alpha acids or humulones to the izo –alpha-acids or izohumulones via an acyloin- type ring contraction. Each humulones gives rise to two epimeric izohumulones, which are known as cis-isohumulones and trans izohumulones.

The izomerization of alpha-acids to izo-α-acids during wort boiling suffers from low yield, which are no more than 30%. The transfer of alpha acids from the vegetative hop material, the restricted solubility on the aqueos matrix and the wort (pH= 5-5,5) are critical factor. The improving hop utilization is very important for beer quality and financial performances of the brewing.

2. Materials and Method

Material. The experiments were conducted using two hops varieties: Magnum and Perle from romanian cultivars. Magnum is a variety derivated from Hallertau with a robust aroma and a strong but clean bitterness. The α –acids rating is usually 12 -14%. Perle is an aroma cultivar brad in Germany from English Northeren Brewer. It is a very versatile hop combining good bittering potential with a highly acceptable aroma that is pleasant and slightly spicy. It's alpha acid ranges from 7- 9.5%.

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Methods for analyses of hop active bittering compound in hop varieties used in experiment consist of determination of alpha acid concentration by Lead Conductance Value (LCV) according to method 7.4 from Analityca EBC. Alpha-acids form lead salts which are insoluble in methanol. A solution of lead acetate / acetic acid is titrated into a methanol solution of hop extract while monitoring conductance; initially there is no change in conductance as a yellow lead salt of the α-acids precipitates. Then the conductance increases: extrapolation of the two straight line curves gives the end point. For determination of hops bittering concentration it was used a Titration system wih automatic sample changer from Schott Instruments.

The traditional and internationally approved method for bitterness determination in beer involves the extraction of iso-alpha acids from acidified beer into iso-octane, followed by a centrifugation step, and photometric measurement at a wavelength of 275 nm against a reference of pure isooctane (European Brewery Convention, 2006, Analytica-EBC, 7.8.). The optical density of the acidified solvent extract is multiplied by a factor to produce an analytical value, measured as Bitterness Units (BU)= Optical Density at 275 nm x 50. The apparatus for determination of bittering units is an UV- VIS spectrophotometer typ UV 1700 from Schimadzu Instruments.

For improving hop utilization, the brewing trials are conducted to identified the critical point of izomerization: pH, temperature, wort boiling time and wort concentration (o Plato).

3. Results and Discussion

The qualitative and cantitative characteristics of Magnum and Perle hops pellets varieties are presented in table 1.

Value for determination of % alphaacids are the means of five replicates.

Table 1. Alpha acid content (w/w) in Magnum and Perle hop pellets

Hop Varietes	Moisture content %	Lead Acetate Titer	Mass sample (g)	Volum lead acetate (ml)	Alphaacids (dry matter) (%)
Magnum	7,59	1,9974	10,00	7,65	13,253±0,269
Perle	7,03	1,9974	10,00	1,98	7,790±0,178

During wort boiling insoluble α-acids are converted to soluble and bitter iso-α-acids. To increase conversion of α-acids you have to control the wort boiling parameters: slightly alkaline conditions, divalent metal ions (especially Mg^{2+}) as a catalyst, boiling times.

In the context of wort boiling, conditions are much more difficult to control and many other reactions can occur.

Humulones have many double bonds and harsh conditions such as boiling in the presence of air results in a number of reactions and a complex mixture of products, some of which are bitter tasting and some are not. The brewing trials were carried off to improve the isomerization of alpha acids into iso-alpha acids during wort boiling process. The results are presented in table 2 and 3.

Table 2. Beer analysis in brewing trial with Magnum Hop Variety

Hop Variety		Process Parameter	Bitter units (BU)	Hop Utilisation (%)	Original Gravity (°P)	Wort Colour (EBC)
Magnum	Boiling time	60 min	20(±0,87)	25,00	12,02 (±0,24)*	6,3(±0,8)
		90 min	21(±0,79)	26,25	12.04(±0,27)	6,4(±1,2)
		120 min	22(±0,83)	27,50	12,03(±0,22)	6,5(±1,1)
	Conc.	10°P	24(±0,81)	30.00	-	6,4(±0,8)
		12°P	23(±0,78)	28,75	-	6,5(±0,5)
		14°P	23(±0,80)	27,50	-	6,5(±0,7)
	pH	5,1	22(±0,83)	27,50	12,10 (±0,25)	6,4(±0,6)
		5,5	28(±0,85)	35,00	12,06 (±0,20)	6,5(±0,6)
		5,8	33(±0,87)	41,25	12,05 (±0,24)	6,5(±0,9)

Table 3. Beer analysis in brewing trial with Perle Hop Variety

Hop Variety		Process Parameter	Bitter units (BU)	Hop Utilisation (%)	Original Gravity (°P)	Wort Colour (EBC)
Perle	Boiling time	60 min	18(±0,75)	22,50	12,08 (±0,26)	6,5(±0,8)
		90 min	19(±0,77)	23,75	12.04(±0,37)	6,5(±0,9)
		120 min	20(±0,81)	25,00	12,02(±0,26)	6,7(±1,2)
	Conc.	10°P	20(±0,83)	25,00	-	6,5(±0,9)
		12°P	20(±0,74)	25,00	-	6,7(±0,9)
		14°P	19(±0,84)	23,75	-	6,(7±0,6)
	pH	5,1	20(±0,73)	25,00	12,09 (±0,32)	6,5(±0,8)
		5,5	24(±0,75)	30,00	12,02 (±0,40)	6,7(±0,5)
		5,8	26(±0,77)	32,50	12,03 (±0,34)	6,9(±0,9)

The results of laboratory experiments demonstrate that the hop varieties with high alpha (Magnum) acids contents have a better utilization in wort kettle than low alpha hops (Perle). This yield, increase with boiling time, wort concentration and pH. Unfortunately, the high pH value is not a good decision because a lot of unlikable reactions could be develop for other wort chemical compounds (proteins and poliphenols).

4. Conclusion

The boiling wort process is important for the production of bittering compounds from the isomerisation of hop alpha acids. Isomerisation is a chemical process which involves molecules being converted from one configuration to another. Alpha acids are dubbed iso-alpha acids once isomerised but they contain the same amount of atoms, merely in a different configuration. The isomerisation reaction is favored by alkaline conditions with a pH of around 9 being optimal, but these conditions are never met during the boil and this explains the notoriously poor level of hop utilization during the brewing process which rarely exceeds 40%. Wort becomes steadily more acidic during the boil due to the formation of break material so the extraction of bittering compounds becomes less efficient as the boil goes on. Along with specific pH conditions, magnesium or another divalent ion and a vigorous boil are required to carry out the isomerisation reaction.

The gravity of the wort can further influence the isomerisation reaction with high gravity worts impeding the progress of the isomerisation step. The loss of precious bittering compounds is bad enough, but the brewers can expect to further lose what little bittering has been achieved through adsorption to yeast and filter material and also some will be scrubbed by CO2 production during fermentation. The pH is the most important parameter in hop utilisation. The high isomerisation is achieved at 5,8, but unfortunatly this pH level is not allowed for wort boiling in normal boiling run. In this situation the brewers have to choise the optimum pH for beer quality, which is 5,1-5,2 , even the hop utilisation is lower.

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