Influence of Hops Pellets Age on α-acids Utilization and Organoleptic Quality of Beer

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Summary

Parallel brewing trials were performed in laboratory brewery. For beer wort hopping, hop pellets of different age ("slightly aged" and "strongly aged" one) and storage indexes (0.35 and 0.59, respectively) were used. During brewing were measured bitterness, utilization of α-acids and index of α-acids isomerization. Mature beers were evaluated by panel taste testing. The results of panel testing, based on beer bitterness, drink ability and aroma, by universal flexible system of product quality evaluation, showed no significant difference between two beers. Therefore it was concluded that old hop pellets with high hop storage index values (0.59) could be used for beer wort hopping when fresh hop supply is missing. However such solution needs prolonged wort boiling, more energy consumption and colour of hopped wort and final beer is more intensive.

Key words

hop pellets type 90, α-acids, hop storage index (HSI), index of α-acids isomerization, utilization of α-acids, universal flexible system of product quality evaluation

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Introduction

Hop quality is the indicator for the condition in which hop constituents are when being added to the beer wort, i.e. the quality indicates whether degradation took place from picking to dosage. Consequently, hop quality is the same as 'degree of freshness'. This expression has hardly been used in the hop industry, but "ageing components, indicate the reduction of hop quality" (Forster, 2001a; 2003a; b).

Benitez et al. (1997) warned that warm conditions during the storage of hop pellets should be avoided. Namely, the formation of gas within the pack, due to chemical reactions, can cause rupture of the foil. This inevitably leads to oxidation or even to the total spoilage of the pellets. Care should also be taken during the transport to avoid excessively high temperatures (Forster, 2002). However, the quality of hop pellets has a very complex nature. It depends not only on the storage temperature, but is effected by many critical steps of hop quality chain, such as: year of vintage, harvest steps (picking of hop cones, drying, conditioning, packing of hop cones into hop bales), storage in form of hop cones, processing into hop pellets and their packaging, storage of packed hop cones, transport to the brewery, storage in the brewery and finally dosing of hop pellets into a wort and its boiling (Forster, 2001a; b). Consequently, it is impossible to separate only one factor as the most important one, or the most determinative factor of hop quality. Each step in the quality chain of hop pellets could be critical, if the temperature is increased. Therefore, one of the hop quality indicators is hop storage index (HSI). Temperature increase speeds up the oxidation reactions which cause degradation of bitter and aromatic hop substances and consequently decrease the brewing value of hop pellets (Weber et al., 1979; Forster 2001a; 2002; Ikeda et al., 2002; Forster, 2003a; b; Rossbauer and Münsterer 2003; Virant and Majer, 2003; Srečec et al., 2005). In short, HSI is increasing as well. The basic principle of hop chemical compounds degradation is primarily the oxidation of α-acids when they are exposed to air, particularly at high temperatures during kilning, other steps of pellets preparation, transport and storage of pellets in brewery warehouse (Forster, 2001; 2003). However, sometimes it is difficult, expensive and even impossible to decrease the air temperature during all critical steps of hop quality chain, but is necessary to reduce the time of hops exposure to high temperatures. Still, a practical questions remains: - What to do with hop pellets characterised by high value of HSI? - Are they useful for hopping of wort? - What would be their influence on brewing and beer quality? Nowadays, more than ever, because of poor hop supply at the world market, such questions becomes actual for a number of brewers.

Thus, the aim of this research was to determine the influence of hop pellets age on:

1. Their α-acids utilization and index of α-acids isomerization in brewing, and
2. Evaluation of mature beers hopped with "slightly aged" (HSI = 0.35) and "strongly aged" (HSI = 0.59) hop pellets.

Materials and methods

Experiments were carried out by one's own produced hop pellets type 90 (produced by Gregurovec Hop Co-operative), from dual purpose hop cultivar Aurora, with balanced bitter and aromatic substances (Srečec et al., 2001; Srečec et al., 2004).

"Slightly aged" pellets, stored at 4 to 7 °C in the presence of air for six months, were of medium quality (HSI = 0.35; α-acids content = 8.5 %), and "strongly aged" pellets, stored for one year at 21 °C in the presence of air, were of poor quality (HSI = 0.59 and α-acids content = 4.1 %). Analyses of α-acids content in hop cones and hop pellets were done by EBC Analytica - procedure 7.4 (Forster, 1987; Forster, 1993; Anonymous, 1998) and Hop Storage Index according to ASBC H-6,12 method (Nickerson and Likens, 1979; Anonymous, 1992), respectively. All analyses were done in triplicate.

In order to define the effect of hop quality (shelf life) on beer bitterness and isomerization of α-acids in wort and beer, two parallel brewing tests were done in laboratory brewery. In both cases, wort was prepared by infusion mashing, boiled with hop pellets and after cooling fermented by lager yeast. Primary fermentation was done at 13 °C for five days and secondary at 2 °C for next 21 day, respectively. In the first test, wort was hopped by "slightly aged" hop pellets of HSI = 0.35, α-acids = 8.5 % and boiled for 90 minutes. In the second test, old or "strongly aged" hop pellets of HSI = 0.59, α-acids = 4.1 % were used and boiling time was prolonged up to 105 minutes. In both cases, 8.8 g of α-acids per hL of final (selling) beer was added into copper. First hopping rate, 80 % of calculated weight of hop, was added immediately after the wort started to boil and the second one (20 %) was added 10 minutes before the end of boiling. During fermentation extract concentration in wort (or beer) was monitored by refractometric method. Samples for beer bitterness analysis were taken at the end of secondary fermentation. Determination of beer bitterness and quantity of α- and iso-α-acids was done by EBC Analytica - procedure 9.8 (Anonymous 1998) and MEBAK 2.22.2., respectively.

Index of α-acids isomerization in beer was calculated by equation 1:

$$I_A = \frac{A_2}{A_2 + A_1} \; 100 \qquad (1),$$

Table 1. Important beer sensory characteristics and their evaluation

Characteristics	Importnace (*fi*)	Evaluation (*qi*) and description
Aroma	0.3	1 – very bad; presence of foreign/strange smells 2 – bad; but without foreign smells 3 – good/satisfied 4 – very good 5 – excellent; a typical hoppy aroma
Taste (or drink ability)	0.2	1 – very bad 2 – satisfied 3 – good 4 – very good 5 – excellent drink ability
Bitterness	0.5	1 – very rough; "burning" my throat 2 – rough; I can feel it on the beginning of my tongue only 3 – good: I can feel it on my whole tongue 4 – very good: I can fell it from the middle part to the end of my tongue but not on my palate 5 – fine bitterness: I can fell it from the middle part to the end of my tongue and on my palate
	$\Sigma fi = 1.0$	

where:
I_A = index of α-acids isomerization,
A_1 = concentration of α-acids in beer,
A_2= concentration of iso-α-acids in beer.

Utilization of hop bitter substances (U_B) in brewing was calculated by equation 2:

$$U_B = \frac{B_B}{B_W} 100 \quad (2),$$

where:
B_W = concentration of hop bitter substances in wort,
B_B = concentration of hop bitter substances in beer.

Statistical analysis of analytical values were provided by using the t-test for depended and small samples, where x and y values was treated as $x = x_i - \bar{x}$ and $y = y_i - \bar{y}$.

Organoleptic panel beer testing was done by the universal flexible system of product quality evaluation (Grujić and Gaćeša, 2001). The 17 judgers, 15 women and two men, were chosen from the population of academic staff and students of Biotechnology at Faculty of Food Technology and Biotechnology. Between testing of each beer sample every judger consumed toast and water to neutralize their sensorial receptors and there weren't any communication between them during the testing. There were three beer characteristics evaluated: aroma, taste (drink ability) and bitterness. Each of beer sensory characteristics was evaluated by "school" marks from 1 (very bad) to 5 (excellent) and the importance of each characteristic was also evaluated (Table 1).

After sensory evaluation the final mark of beer organoleptic quality was calculated by equation 3:

$$B_Q = \frac{\sum fi \cdot qi}{\sum fi} \quad (3),$$

where:
B_Q = beer organoleptic quality
fi = importance of each characteristic
qi = mark for each characteristic

Results and disccusion

Two brewing tests were performed to define the effect of hop quality (age) on the beer bitterness and α-acids isomerization. In both tests the fermentation was quite normal; it means that using of aged hop pellets have no negative influence on yeasts activity (Figure 1). In first test, wort was hopped by "slightly aged" pellets of medium quality. A hop bitter substance adsorbs on suspended parts of wort and yeast cells and therefore its concentration decreases consequently from wort to the green and mature beer. In the second test, wort was hopped by "strongly aged", poor quality hop pellets. Due to the relatively high

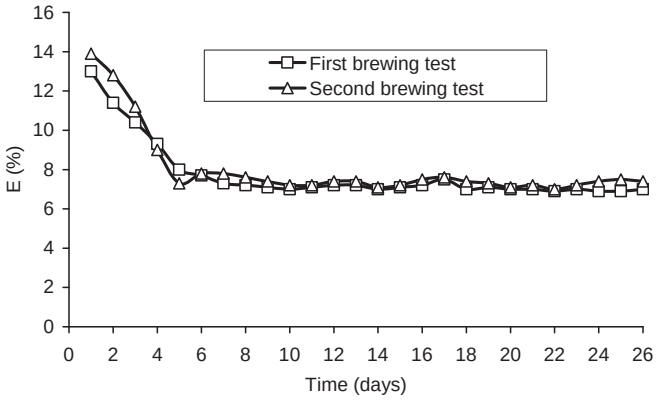

Figure 1. Changes of extract concentration during fermentation in two parallel brewing tests

Table 2. Results of panel taste testing of beer from first brewing test ($n_{(assessors)}$ = 17)

Sensory characteristic	Evaluation (q)		Importance (f)	$f \cdot k$
	Σq	$\bar{q}$		
Aroma	59	3.5	0.3	1.05
Taste (drink ability)	49	2.8	0.2	0.56
Bitterness	60	3.5	0.5	1.75
Σ	–		1	3.36
Final evaluation, $B_Q = \frac{\sum fi \cdot qi}{\sum fi}$	3.36		–	–

Table 3. Results of panel taste testing of beer from second brewing test ($n_{(assessors)}$ = 17)

Sensory characteristic	Evaluation (q)		Importance (f)	$f \cdot k$
	Σq	$\bar{q}$		
Aroma	54	3.2	0.3	0.96
Taste (drink ability)	49	2.9	0.2	0.58
Bitterness	57	3.3	0.5	1.65
Σ	–		1	3.19
Final evaluation, $B_Q = \frac{\sum fi \cdot qi}{\sum fi}$	3.19 ≅ 3.2		–	–

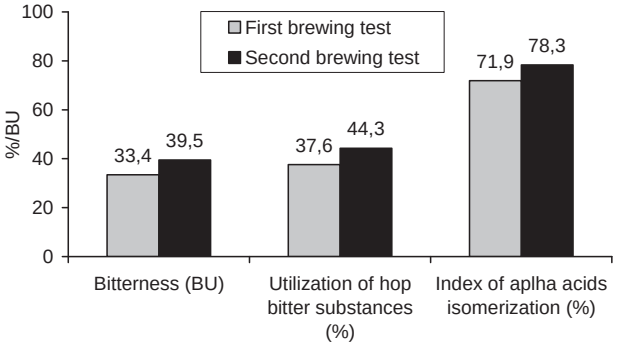

Figure 2. Index of α-acids isomerization, utilization of hop bitter substances and bitterness of mature beers produced in two parallel brewing tests

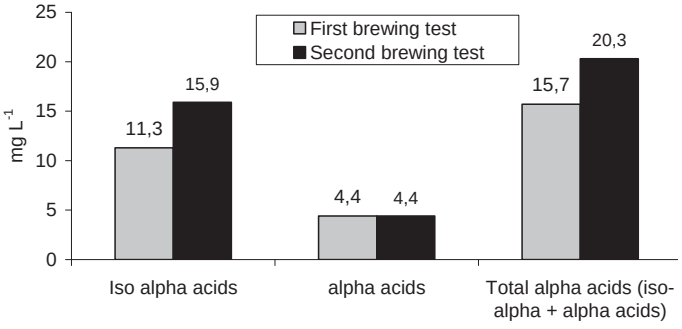

Figure 3. Shares of α- and iso-α-acids in mature beers produced in two parallel brewing tests

HSI value and low α-acids content boiling was prolonged up 105 minutes to obtain adequate amount of iso-α-acids in beer. Results presented in Figure 2 show unexpected high bitterness and utilization of hop bitter substances in both brewing tests, regardless of hop age. At the end of beer maturation bitter substances utilization was 44.3 % and the index of α-acids isomerization was 78.3 %. These results clearly show possibility to achieve a good utilization of hop bitter substances, improvement of the index of α-acids isomerization and beer bitterness by prolonged wort boiling, even when a "strongly aged" hop pellets are used for hopping. A slightly higher iso-α-acids concentration achieved in second brewing test (Figure 3) is related to the higher efficiency of hop bitter substances extraction at prolonged wort boiling. Of course, better (higher) results in the second brewing test can be argued by the accuracy of applied analytical method. Namely, prolonged boiling has more degraded present hop compounds causing increase of absorption measured at 275 nm and consequently higher bitter substance concentrations were detected. Although the applied spectrometric method is easy to carry out (adequate for plant measurement) it does not always well describe beer bitterness and therefore sensory evaluation of bitterness (despite the deficiencies of sensory bitterness evaluation itself) has to be done. Nevertheless, our sensory beer testing did not give significant difference in bitterness between our two brewing tests (Table 2 and 3). Higher analytical data for beer bitterness are often observed when deteriorated ("strongly aged") hop is used, while resulting beer tastes far less bitter than measured bitterness

shows (Stevens 1987, Schönberger, 2006). On the basis of previous discussion it is obvious that for the monitoring of hop isomerization process in brewing would be better to use HPLC method. This method is capable to detect all iso-α-acids (products of α-acids transformation during wort preparation), which have major impact on beer bitterness. Therefore, in our further investigation we shall try to confirm our finding by HPLC method.

Conclusion

The analyses of wort and beer hopped by "strongly aged" pellets stored at 21 °C in the presence of air (HSI = 0.59) have shown possibility to increase isomerization index of α-acids and consequently utilization of bitter hop compounds by prolonged wort boiling in the comparison to beer hopped with "slightly aged" hop pellets (HSI = 0.35). Sensory panel taste testing has not given significant difference in bitterness of two beers produced in parallel brewing tests by hop pellet of different quality. However, use of "strongly aged" hop pellets is not recommendable from energetic and beer colour point of view.

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