Production of light stable beers on a commercial scale

GUARANTEEING STABILITY | About 15 years ago, breweries first started to fill beer into transparent bottles for marketing reasons. Traditional beer drinkers regarded this with some scepticism, though this concept seems to appeal to young people. It became a fashion that is still successful and is even becoming more widespread. The possible product damage caused by UV radiation is a problem that has to be resolved. This article is limited to some practical aspects of using hydrogenated extracts, especially to rho- and tetrahydroiso-alpha acids that are used in the vast majority of cases [1].

THERE ARE MAINLY two possibilities for minimising taste impairment resulting from UV light shining on transparent bottles. On the one hand, reduced pre-isomerised extracts can be used and, on the other hand, specially coated bottles reduce damage to product by UV rays. The second possibility is currently adopted by a number of German breweries who are prevented from using reduced extracts due to the German Purity Law. The way it works has been described in the literature ([2], [3], [4]) and will not be presented in any detail here.

General remarks

To start with, some fundamental factors will be briefly summarised, these are generally known but have to be mentioned for the sake of completeness:

In order to produce perfectly light stable beers, no alpha acids and non-reduced iso-alpha acids should be present in beer. To assure this, yeast that has already been used once in a brew with normal hopping should not be added. It is generally known that yeast absorbs hop bitter and aroma substances, with the consequence that these will be dissolved again in a "light stable" brew and may cause the undesirable lightstruck taste.

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Wort was traditionally fermented in an unhopped state, this led to microbiological problems in some instances, for example to infections of wort and/or green beer. The problem can be resolved by adding beta-extract or rhohydroiso-alpha acid (Rho) to the wort. The bacteriostatic action of these products ultimately prevents propagation of unwanted microorganisms in wort and beer.

In some instances, unhopped wort tends to boil over, especially at the beginning of boiling. This problem can be also addressed by adding beta-extract, though the contribution of same to bitterness is very limited.

It has been noted in commercial operations that reduced extracts make different contributions to beer bitterness. When taking non-reduced iso-alpha acid as a 100% basis, rhohydroiso-alpha acid reaches 60 to 70% and tetrahydroiso-alpha acids (Tetra) 100 to 110% in comparison. This emerged from tests carried out in conjunction with the TU Munich-Weihenstephan [5]. These results have been confirmed, especially for Tetra, by other authors ([6], [7]). In general, our experience has shown that it is expedient to subject the beer in question to pre-tests and tastings as the impression of beer bitterness is influenced by the whole beer matrix.

Dosage of rho- and tetrahydroiso-alpha acids

Only some special aspects of dosage will be mentioned here:

One should never dose after filtration. Downstream products will never go 100% into solution due to their chemical structure. This always involves the danger that undissolved particles are present in filled beer offered for sale.

When dosing ahead of filtration, products should be used that do not need pre-heating or dilution. This is not a problem for Tetra in any event, and Rho is meantime on sale also in a 10% concentration. Both products can thus be dosed directly. Should dilution be required due to dosing capacity, potassium hydroxide is generally used, the pH value has to be set to about 10 to 11. It is also possible to dose Rho and Tetra concentrates immediately ahead of filtration with a dedicated unit [8].

LIGHT STABLE BEER WITH 15 BITTERNESS UNITS (SENSORY IMPRESSION), DOSAGE AHEAD OF FILTRATION

Point of addition	Product	Standardisation	g product hl	g iso hl	BU sensory
ahead of filtration	Tetra	10 %	4,0	0,4	3
ahead of filtration	Rho	10 %	23,0	2,3	12
total					15

Table 1

If dosage is to go directly into the wort, Rho is to be preferred as its solubility in wort is somewhat better than that of Tetra. It is known that, as a result of multiple hydrogenation, solubility in aqueous media, i.e. also in wort or beer, decreases. Rho can also be added to wort as Rho 35% or Rho concentrate, in each instance without prior heating.

Proposals for production of light stable beers

It is indeed possible to produce a light stable beer, using one product only. This simplifies handling in the brewery as well as procurement and stock keeping. Various aspects have to be taken into account:

- If Rho by itself is used, foam stability is improved only insignificantly.
- Using Tetra by itself, foam stability is excellent. But care must also be taken that the foam does not look too artificial or that the solubility limit of Tetra in beer is not exceeded. At a dosage below 20 ppm, this generally does not pose a problem. Using Tetra exclusively might have a negative influence on taste. A metallic or medicinal flavour impression may arise. Again, this is highly dependent on beer type and has to be checked individually in all instances.
- Yields for Tetra range from 60 to 70%, when dosing ahead of filtration. The range is 65 to 75% for Rho. When Rho is added during wort boiling, recovery drops to 45 to 55%.

In an ideal case, we recommend a combination of Rho and Tetra if there is a need to also significantly improve foam. It is recommended to dose Tetra in a quantity required for improving foam stability only. This is usually maximum 4 to 5 mg per litre, corresponding to a concentration of 3 ppm in the finished beer. The remaining bitterness should then be contributed by Rho.

Table 1 is an example of beer with about 15 BU, although this value for bitterness units is not analytically achieved but should be expected in sensory terms. The factor for calculating bitterness units should be higher for pure iso-alpha acids ([9], [10]).

As an alternative, Table 2 shows the possibility of adding Rho during wort boiling, and it has been mentioned that this reduces the danger of infections. In this case, Rho, standardised to 35%, or Rho concentrate can also be used because precipitations or the extract dissolve readily in the hot wort. If a full container is not required in dosing Rho 35%, care should be taken that the contents are well homogenised prior to dosage.

LIGHT STABLE BEER WITH 15 BITTERNESS UNITS (SENSORY IMPRESSION), PART DOSAGE DURING WORT BOILING

Point of addition	Product	Standardisation	g product hl	g iso hl	BU sensory
to wort	Rho	35 %	9,8	3,4	12
ahead of filtration	Tetra	10 %	4,0	0,4	3
total					15

Table 2

It has been found that opinions differ about the flavour impression of these beers. When using iso-alpha acids exclusively in whatever form, there is a lack of bitter substances from the soft and hard resin fraction, as well as all hop aroma substances. Whereas some brewers see this as a benefit because they want to create a new beer type with this new constellation in the form of a transparent bottle, other brewers complain about the absence of hop flavour components.

The latter can be remedied, at least in part. It is generally known that there are various types of hop oils that can be added, together with reduced extracts, ahead of filtration. In order to get a general indication for dosage, a certain linalool concentration in beer can be set as a goal.

Naturally, linalool is not solely responsible for hop aroma in beer but shows a very good correlation ([11], [12]). Table 3 shows that odour impressions also change with increasing concentrations. However, these values are only a general indication based on average values from many test results with different beers. It is essential to run individual pre-tests.

Use of light stable Beta Aroma Extract is another possibility. This is, generally speaking, a CO_2 extract without alpha acids. Consequently, the main components are beta acids and hop oils. The beta acids serve as carrier material for hop aroma substances as only a small number of their breakdown products contribute to beer bitterness. The intensity of hop aroma can be determined via dosage quantity and timing of addition.

If microbiological stabilisation is also an issue, about 7 g of beta acids per hl should be dosed in all cases, based on a beta concentration of 50%, this corresponds to a dosage of 14 g of beta extract. Should it be undesirable to have any hop aroma, the extract should not be dosed later than 30 minutes before the end of boiling. This is, at best, only a general pointer because dissolution of the extract and thus evaporation of hop oils is highly dependent on the type of wort boiling and can vary very significantly.

One can produce beers comparably to those beers produced with conventional CO_2 extract when using another alternative, the Light Stable Kettle Extract, hereinafter referred to as LSKE. LSKE has the same composition as CO_2 extract, with the only difference being that alpha acids have been fully converted to rhohydroiso-alpha acids and that the extract has thus become light stable.

It goes without saying that LSKE has to be added in the brewhouse. As described above, Tetra can be dosed ahead of filtration

CHANGE OF AROMA IMPRESSION WITH INCREASING CONCENTRATIONS OF LINALOOL INDICATOR SUBSTANCE IN FINISHED BEER

Linalool concentration	Aroma impression
as of 20 µg	pleasantly typical of hops
as of 40 µg	flowery hop note
as of 60 µg	additional citrus aroma

Table 3

in the event of foam problems, this has to be taken into account in terms of dosage. As far as yield is concerned, LSKE is comparable to Rho 35% or Rho concentrate, at 45 to 55%. Likewise, a factor for the weaker sensory bitterness impression has to be taken into account. Table 4 shows another dosage example for a light stable beer which is analogous to that in Table 2, with 15 bitterness units ascertained by sensory tests.

The time of dosage to the wort is again a function of the dissolution of the rhoiso-alpha acids during boiling and of the hop aroma desired. A maximum of 20 minutes boiling time is required for complete dissolution. At the same time, it is possible to achieve a pronounced hop aroma when adhering to this boiling time. If this is not desired, boiling time for the extract can be prolonged, without loss of bitter substances. It is also conceivable to split LSKE addition.

LIGHT STABLE BEER WITH 15 BITTERNESS UNITS (SENSORY IMPRESSION), PART DOSAGE DURING WORT BOILING

Point of addition	Product	Standardisation	g product hl	g iso hl	BU sensory
to wort	LSKE	40%	8,6	3,4	12
ahead of filtration	Tetra	10%	4,0	0,4	3
total					15

Table 4

Analytical problems

Determination of bitterness units according to Analytica EBC 9.8 is a very valuable method for practitioners because it can be carried out relatively easily and has a good correlation with sensory bitterness because it also includes the "non-iso-alpha-bitterness" in the analysis. Unfortunately, it is of limited usefulness for beers produced exclusively with iso products, as described under 1 of the chapter "Proposals for production of light stable beers".

There are a number of investigations ([6], [9], [10]) comparing tetrahydroiso-alpha or rhohydroiso-alpha and bitterness units, these, however, lead to different results.

Some tests of beers from different breweries, produced with different downstream products, have very different outcomes. Tetra and Rho, determined according to HPLC EBC 7.9, range from 10 to 40% above the bitterness units according to EBC 9.8, individually or as a mixture. However, a very much more differentiated approach is needed, requiring a very large number of analyses. Again, the beer matrix seems to have an influence.

Summary

Production of the first light stable beers repeatedly led to complaints about hop aroma and hop bitterness. This was plausible because, when using pure downstream products, only iso-alpha acid was dosed and a whole range of important hop components were missing. In the course of time, this could be improved by additional light stable products which again contributed slightly more hop character to beers. But it should not be forgotten that various breweries were intentionally creating a different novel taste such that beer in transparent bottles would be distinguishable from conventional beers, also in terms of taste.

This article describes various possibilities of producing light stable beers. This ensures that not all beers have the same bitterness and the same hop aroma.

Sufficient data is not yet available in order to demonstrate a better correlation between bitterness units and the respective reduced iso-alpha acids in beers. This could significantly simplify operational controls in breweries because the HPLC method requires very extensive sample preparation and chromatography also takes quite a lot of time.

The future will show whether light stable beers are simply a passing fad or whether they can succeed in establishing themselves on the market over a longer period. The trend also seems to differ quite considerably from one country to another. ■

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