A Novel Mash Filtration Process (Part 4)

FACTORS INFLUENCING FERMENTATION AND BEER QUALITY | Nessie by Ziemann® is a revolutionary new lautering procedure in beer production that may have a lasting effect on conventional brewhouse operations. BRAUWELT International is taking a comprehensive look at this interesting technological innovation in a series of articles from all relevant perspectives. Part 4 considers the influences of changes in wort composition on fermentation, conditioning, and storage unit operations.

THE OBJECTIVE of all brewers is to produce a uniform beer quality in the most cost-effective manner possible. Given standard, highly sophisticated lauter systems with a mash filter and lauter tun, there is, however, very little room remaining for further improvements.

With the novel mash filtration system referred to as Nessie by Ziemann (Fig. 1), new opportunities arise for brewing specialists in terms of raw material selection, lautering parameters, temperature and concentration and brewhouse configuration. On the one hand, lautering is now the pacemaker in the brewhouse – the procedure opens the door to continuous brewing. On the other hand, wort composition and hop balances are changing. Both have been described in detail in previous articles [1-3].

In the fourth part of this series, this interrelationship is explored by looking at the downstream unit operations of fermentation, conditioning and storage, up to quality of the bottled beer.

Test Setup

Lauter tun wort prepared from identical raw materials was used as a control. Malt quality met the requirements of DIN 8777. The cast wort volume in the Nessie mash filtration system was 46 hl. More information about brewhouse parameters selected are summarised in Table 1 and Fig. 2.

The samples were fermented with bottom-fermenting yeast proven to be successful on a commercial scale. The number of pitching yeast cells was 13 million cells/ml for the lauter tun brews, and 20 million cells/ml for Nessie brews. Unlike the lauter tun brews aerated at 13 ppm, just 20 per cent of the wort quantity in Nessie brews was aerated (10 ppm).

Metals

In general, Nessie worts have higher levels of metal ions [4]. A very basic rule of thumb states that: as the trub load in the wort goes up, its metal ion concentration also rises as metals are absorbed by hydrophobic particles [5-10]. In conventional filtration, metals are significantly depleted on the large surface area of the spent grains cake. Smaller quantities are thus transferred into the lautering wort. The novel lautering procedure overcompensates for this 'under-balancing' by far (Fig. 3).

Foto: K. Glauner

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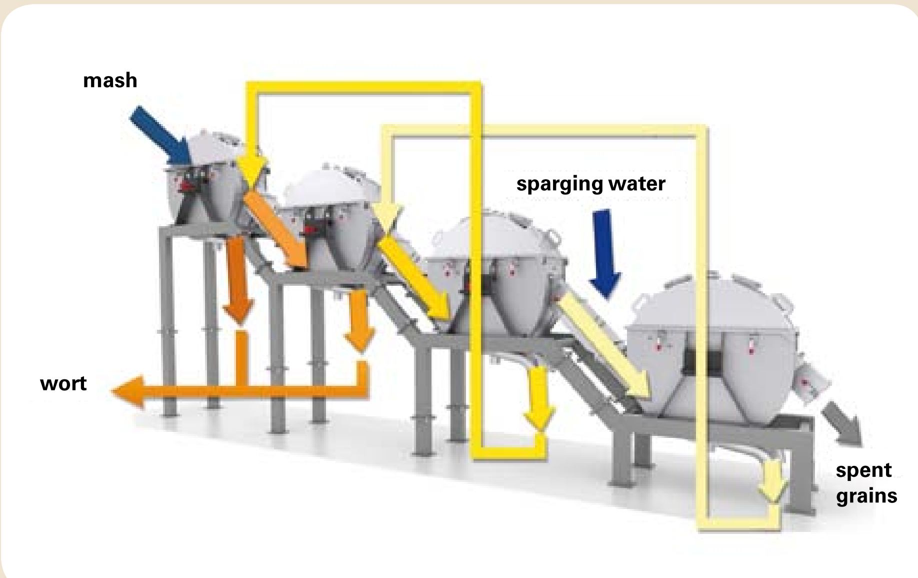

Fig. 1 Process diagram of the novel mash filtration system

Brewing specialists will be interested in the fact that copper and iron are present at same levels but that manganese and especially zinc are significantly elevated. This is important given that zinc is essential for yeast vitality. A powerful "fermentation accelerator" is thus introduced into Nessie brews.

Fatty Acids

Apart from high levels of minerals, more fatty acids are found in hazier worts. Long-chain fatty acids can be oxidised enzymatically and chemically, resulting in undesirable aroma substances and thus reducing flavour stability of finished beer [11]. Despite this rather negative sensitivity to oxidation, fatty acids have a positive physiological effect on yeast.

Fatty acids are constituents of yeast cell walls. Yeast is able to either auto-synthesise fatty acids involving high energy input (only possible via aerobic yeast metabolism) [12], or it can absorb and process them. Yeast readily accepts this "reduced workload". Fatty acids in the fermentation substrate are therefore quickly and almost completely metabolised.

Although levels of higher-chain fatty acids using Nessie are above those from the lauter tun, levels are lower in finished beer (Fig. 4). The stimulating effect of turbidity on fermentation activity of yeast is apparent, e.g. in extract breakdown. This is accelerated compared to the lauter tun (Fig. 5). This means that the actual dwell time in the tank is shorter, equivalent to a higher fermentation cellar capacity. In view of good yeast vitality in Nessie brews, it is also easily possible to control extract breakdown by adjusting fermentation temperature.

The question arises as to why one tried in the past to obtain bright lautering wort and why cold break separation was done at all. Cold break separation was previously strongly recommended as the trub load from the lautering, boiling, and whirlpool processes was very high. At the same time, yeast management was not optimal so that the trub caused "smearing" of the surfaces of yeast cells, which in turn impacted negatively on fermentation.

Low-protein and high modification malt due to progress in breeding, good mashing work with optimised agitators, bright lautering worts, intensive boiling processes with high levels of protein coagulation and brewing worts low in solids resulting

BREWHOUSE PARAMETERS OF NESSIE WORTS

Liquor ratio:	3.0 l/kg
Acidification:	H_3PO_4
Mash pH:	5.2
Hop addition:	2.7 kg (alpha acid content = 13,7 %)
Boiling time:	55 min
Total evaporation:	6 %

Table 1

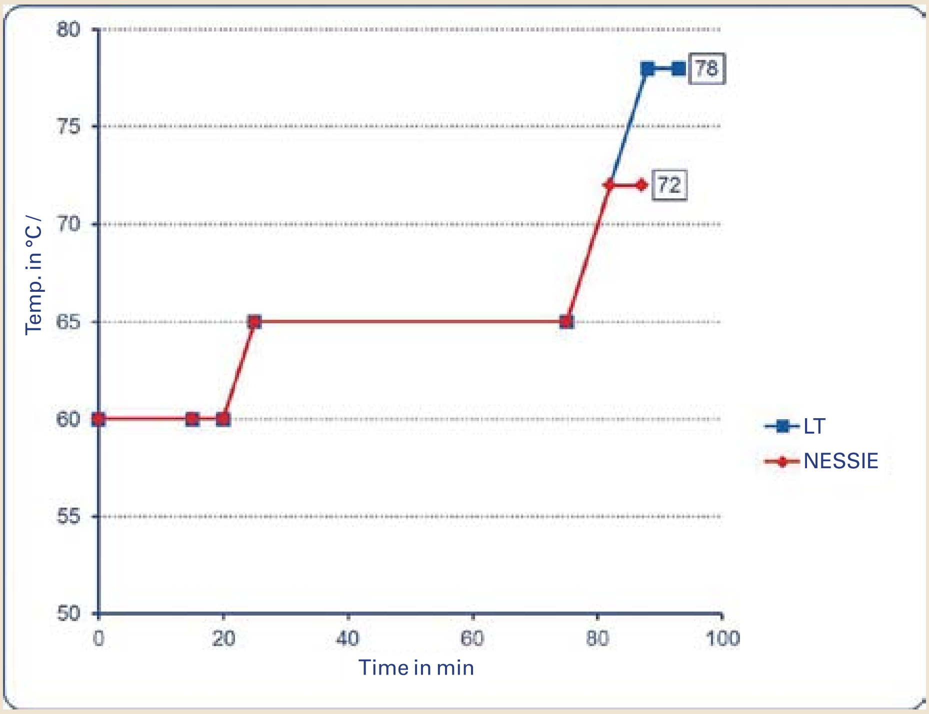

Fig.2 Mashing procedure

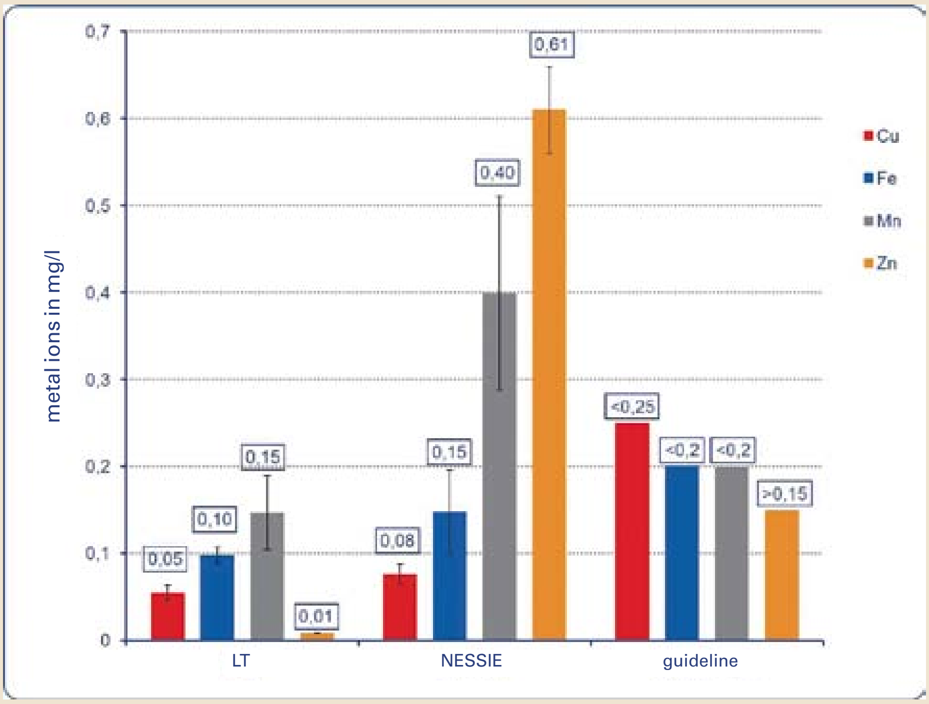

Fig. 3 Metal ions in half-time cooling wort (n=3-5, α=0.05)

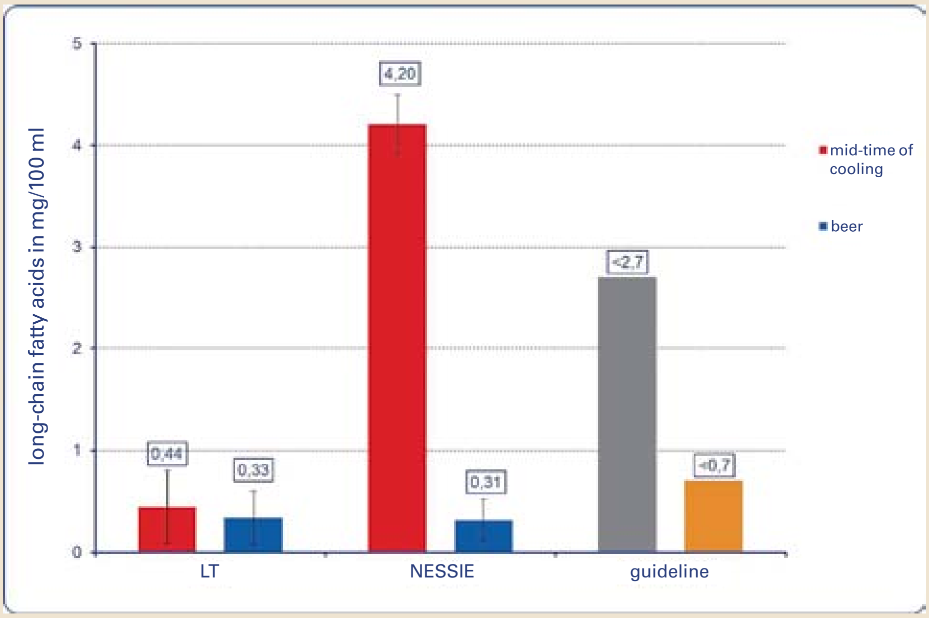

Fig.4 Long-chain fatty acids at half-time of cooling and in beer: palmitic, stearic, oleic, linoleic and linolenic acids (n=2-5, α=0.05)

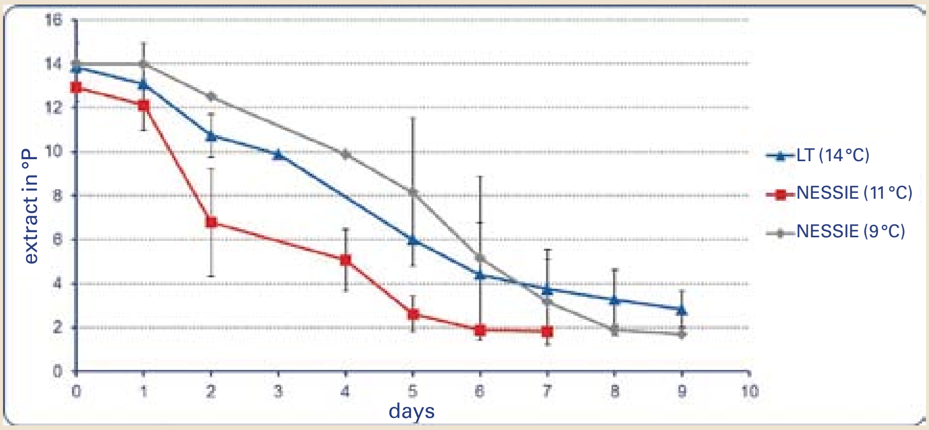

Fig.5 Progress of extract in Nessie and lauter tun worts (n=2-5, α=0.05)

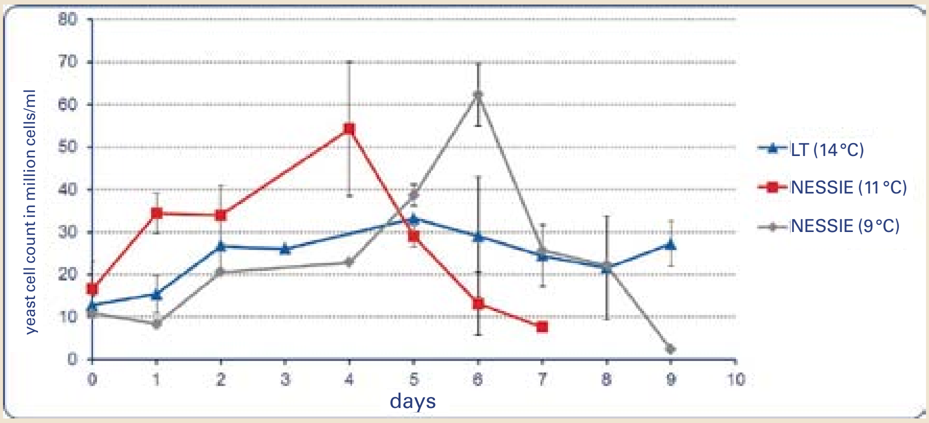

Fig. 6 Yeast cell count during fermentation of Nessie and lauter tun worts (n=2-5, α=0.05)

from improved hot break separation in the whirlpool are standard today. Such progress mitigated the turbidity problem or actually overcompensated for it. This explains why many brewers have decided to dispense with separation of cold break.

At the same time, worts come into contact with high vitality pitching yeasts placed in cold interim storage after harvesting or even assimilated. There is thus a lack of vital substances important for yeast. Nessie makes use of this new situation and counters this deficiency by using hazy worts.

A greater supply of fatty acids also promotes anabolism of yeast, evidenced by higher yeast multiplication/yeast cell counts in the course of fermentation (Fig. 6). The yeast population thus rejuvenates, a generally beneficial result. In control brews, yeast cell count rises only slowly, a clear indication of weakened yeast and therefore sluggish fermentation.

Cell count is very sensitive to temperature (Fig. 6), similar to development of extract. This is another tool suitable for controlling ongoing fermentation.

The yeast-stimulating effect of Nessie worts is observed both during primary and secondary fermentation. Diacetyl, a very important parameter, is a good tool for tracking this development. This aroma substance is formed extracellular during primary fermentation due to decarboxylation from α-acetolactate in the context of amino acid synthesis. Although diacetyl reinforces the body of beer but, being the main flavouring agent in butter and yogurt, it tends to be perceived negatively in sensory terms if the taste threshold of the particular beer is exceeded. It is also very intense. The taste threshold in beer is just 0.1 mg/l.

To counter this off-flavour, yeast has to reabsorb diacetyl and reduce it to the taste-neutral 2,3-butanediol via acetoin. However, only active yeast cells are able to push down diacetyl to below taste threshold [13]. In traditional brewing processes, krausen – i.e. actively fermenting beer in a good yeast physiological condition, are added among other substances after fermentation proper. Thanks to the strong fermentation activity in Nessie worts, also reflected by extract breakdown, a higher maximum amount of diacetyl is also obtained (Tab. 2). During secondary fermentation, diacetyl is still broken down more rapidly as a result of good yeast vitality. This faster breakdown of diacetyl reduces the dwell time in the tank further, thus cellar capacity in the case of Nessie worts goes up.

Higher levels of medium-chain fatty acids in beer are a clear sign that yeast autolysis has already taken place. Old, weakened yeast cells are responsible for this. They not only halt their metabolism processes sooner, they also have sensitive cell walls that dissolve and thus transfer intra-cellular fatty acids into the surrounding beer. These medium-chain fatty acids are significantly lower in Nessie brews than in the control (Fig. 7) as yeast cells are physiologically healthier.

Polyphenols

Total polyphenols and anthocyanogens are also important parameters for beer quality. Levels are reduced by around one third in Nessie worts as contact time between spent grains and second worts, and thus leaching of husks, is significantly lower during lautering (Fig. 8).

Fermentation By-Products

Levels of acetaldehyde, higher alcohols and fatty acid esters, relevant by-products of fermentation, are the same as in lauter tun control beer. The exception is ethyl acetate which – at 6.5 mg/l – is considerably lower than that measured in the lauter tun (29 mg/l) (Fig. 9). Ethyl acetate is described as fruity and solvent-like. It plays a role in the aroma profile of beer but should not become too dominant in beers stored for too long a period. The literature mentions a guideline figure for ethyl acetate of 5 to 20 mg/l for light full beers [11].

It can generally be said that the aroma profile of Nessie beers, as of all beers, can be adjusted by changing fermentation parameters. But properties mentioned above for fermentation of Nessie wort should also be taken into consideration.

Conclusion

Nessie worts have a significantly higher amount of vital substances for yeast. These include, in particular, zinc and long-chain fatty acids. This factor accelerates fermentation significantly, resulting in a larger fermentation cellar capacity due to a shorter dwell time in the tank.

More vital yeast also improves flavour stability of beers. This important factor is supported by a low thermal load in the novel brewhouse process as a whole, evidenced analytically by Maillard reaction products, furfural and TBI parameters for example.

This article, however, describes only the main properties of beer production with Nessie worts, based on selected data. Follow-up tests on a pilot and commercial scale are planned and will be published in subsequent papers. Scientists and practitioners can look forward to future developments.

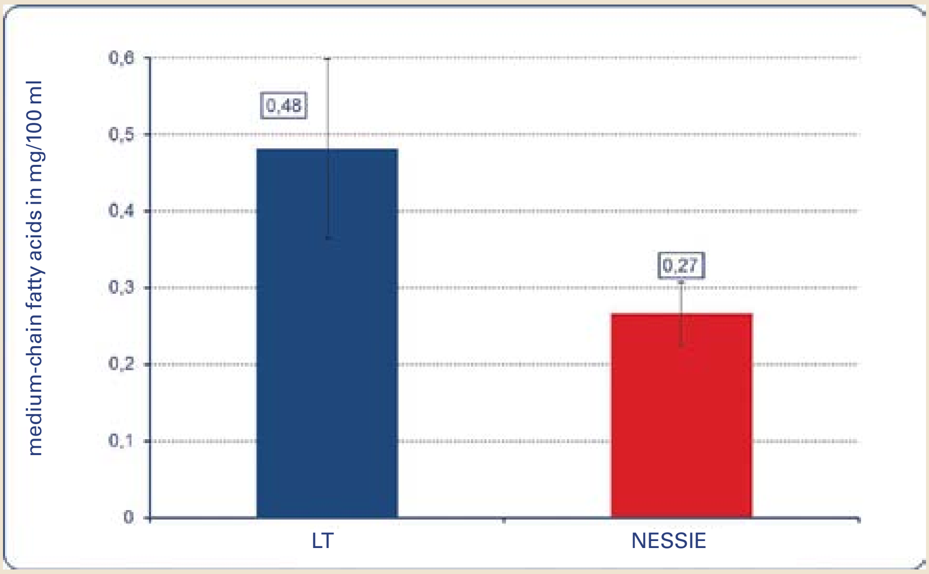

Fig.7 Medium-chain fatty acids (caprylic, capric and lauric acid) in beer (n=2-4, α=0.05)

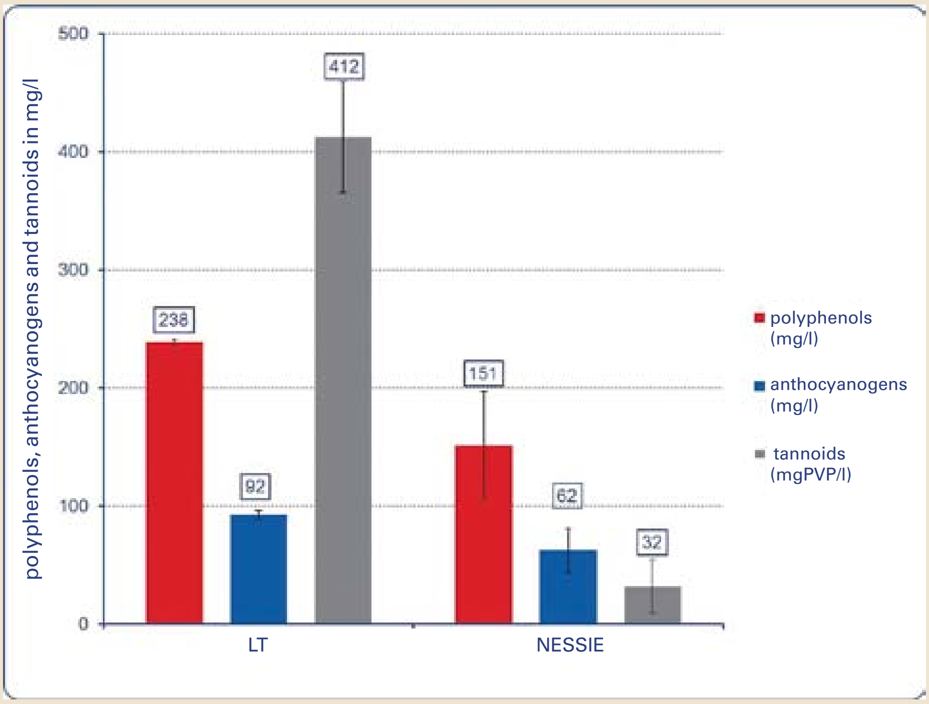

Fig.8 Total polyphenols, anthocyanogens and tannoids in worts (n=3-5, α=0.05)

DIACETYL VALUES DURING FERMENTATION

	Max. diacetyl value in µg/l	Final diacetyl value in µg/l
LT (14 °C)	522	73
Nessie (9 °C)	890	126
Nessie (11 °C)	1486	82

Table 2

Literature

1. Becher, T.; Ziller, K.; Wasmuht, K.; Gehrig, K.: "A Novel Mash Filtration Process (Part 1)", in: BRAUWELT International No. 3, 2017, pp. 191-194.
2. Bastgen, N.; Wasmuht, K.: "A Novel Mash Filtration Process (Part 2: Fractional Wort Boiling"), in: BRAUWELT International No. 4, 2017, pp. 270-273.
3. Schwill-Miedaner, A.; Miedaner, H.:

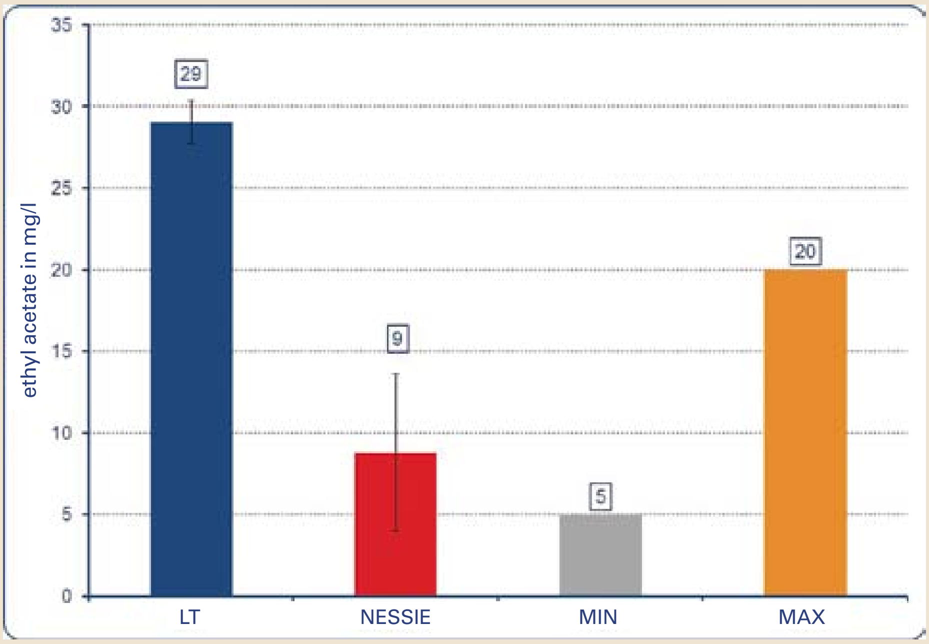

Fig. 9 Ethyl acetate in beer (n=2-4, α=0.05)

"Neues Verfahren der Maischefiltration (Teil 3: Technologie der Würzebereitung im Fokus)", in: BRAUWELT No. 18-19, 2017, pp. 545-548.
4. Dickel, T.; Krottenthaler, M.; Back, W.: "Studies into the influence of the cold break insertion on beer quality", in: Monatsschrift für Brauwissenschaft, 53, No. 5-6, 2000, pp. 95-100.
5. Kühbeck, F.; Back, W.; Krottenthaler, M.; Kurz, T.: "Particle Size Distribution in Wort during Large Scale Brewhouse Operations", in: Aiche Journal, 53, No. 5, 2007, pp. 1373-1388.
6. Kühbeck, F.; Müller, M.; Back, W.; Kurz, T.; Krottenthaler, M.: "Effect of Hot Trub and Particle Addition on Fermentation Performance of Saccharomyces cerevisiae", in: Enzyme and Microbial Technology, 41, 2007, pp. 711-720.
7. Kühbeck, F.; Schütz, M.; Thiele, F.; Krottenthaler, M.; Back, W.: "Influence of Lauter Turbidity and Hot Trub on Wort Composition, Fermentation, and Beer Quality", in: Journal of the American Society of Brewing Chemists, 64, No. 1, 2006, pp. 16-28.
8. Kühbeck, F.; Back, W.; Krottenthaler, M.: "Influence of Lauter Turbidity on Wort Composition, Fermentation Performance and Beer Quality – A Review"; in: Journal of the Institute of Brewing, 112, No. 3, pp. 215-221.
9. Kühbeck, F.; Back, W.; Krottenthaler, M.: "Influence of Lauter Turbidity on Wort Composition, Fermentation Performance and Beer Quality in Large-Scale Trials", in: Journal of the Institute of Brewing, 112, No. 3, 2006, pp. 222-231.
10. Kühbeck, F.; Back, W.; Krottenthaler, M.: "Release of Long-Chain Fatty Acids and Zinc from Hot Trub to Wort", in: Monatsschrift für Brauwissenschaft, 59, 2006, pp. 67-77.
11. Back, W.; Krottenthaler, M.; Bohak, I.; Dickel, T.; Franz, O.; Hanke, S.; Hartmann, K.; Herrmann, M.; Kaltner, D.; Keßler, M.; Kreisz, S.; Kühbeck, F.; Mezger, R.; Narziss, L.; Schneeberger, M.; Schütz, M.; Schönberger, C.; Spieleder, E.; Thiele, F.; Vetterlein, K.; Wunderlich, S.; Wurzbacher, M.; Zarnkow, M.; Zürcher, J.: Ausgewählte Kapitel der Brauereitechnologie, Fachverlag Hans Carl, Nuremberg, 1st Edition 2005, 2nd Edition 2008.
12. Brewing Yeast & Fermentation; Chris Boulton & David Quain, Blackwell Science Ltd./Wiley, www.blackwellpublishing.com, ISBN: 13:978-1-4051-5268-6.
13. Back, W.; Krottenthaler, M.; Braun, T.: "Untersuchungen zur kontinuierlichen Bierreifung" in: BRAUWELT, No. 3-4, 1998, pp. 70-73; Back, W.; Krottenthaler, M.; Braun, T.: "Investigations into continuous beer maturation", in: BRAUWELT International, 16, 1998, No. 3, pp. 222-226.
14. Narziß, L.; Back, W.: Die Bierbrauerei Band 2: Die Technologie der Würzebereitung, Wiley-VCH, Hoboken, 2009.
15. Krottenthaler, M.: "Entwicklung innovativer Technologien zur Optimierung der Würze- und Bierqualität", Munich, TUM School of Life Sciences Weihenstephan, habilitation treatise, 2007.