Kettle Hop Products to Optimize Alcohol-Free Beers

Using Extracts makes The Difference

(All images Hopsteiner)

Non-alcoholic beers (NAB) are more popular than ever, and their production and optimization continue to be at the forefront of the brewing industry. In 2022, the share of NAB in Germany was 6.7% [1], and globally it was approximately 4.2% [2]. Depending on the production technique, NABs have a distinct character. The choice of hop product and hop recipe are ways to shape the overall impression of the beer.

Classical Hop Products In accordance with the purity law, hop addition in the brewhouse is allowed with whole hops, hop pellets (Type 90 and Type 45), as well as conventional extracts. The latter are produced either using supercritical CO_2 or fermentation alcohol. When using whole hops and pellets, all chemical groups and variety-specific hop constituents are introduced into the beer, making an impact both sensorially and technologically. Extracts, on the other hand, essentially contain only two brewing-relevant substance groups, the variety-specific bitter and aroma compounds. The composition of bitter compounds is a crucial differentiating factor between the two conventional extracts. Supercritical CO_2 extract mainly contains the soft resins of hops, while the extract obtained with ethanol includes all variety-specific bitter compounds. This difference in bitter compound composition can account for up to 10% of the total bitter compound content of the extract, depending on the hop variety used [3]. Table 1 illustrates the differences between the three conventional hop products used in this study.

Review

From previous experiments conducted in 2017 at the Chair of Brewing and Beverage Technology, it was already shown that the type of hop addition (product & timing) has a sensory influence on thermally dealcoholized beer. Different expressions of bitterness, especially in terms of bitterness quality, were attributed to the different hop products added at the beginning of the boil. Regarding hop aroma, it was sensorially and analytically confirmed in these experiments that after thermal dealcoholization, almost no hop aroma compounds remain in the NAB, even with a very aromatic whirlpool hopping in the mother beer the corresponding mother beers (> 100µg/l

Table 1: Overview of the used conventional hop products used

	Pellets Type 90 (P90)	CO_2 - Extract (COX)	Total Resin Extract (TRX)
Starting material	leaf hops	hop pellets	leaf hops
Extraction solvent	no solvents used only mechanical processing	carbon dioxide (supercritical)	fermentation alcohol
Key components in the product	all bittering compounds all hop oils all polyhenols all other components	the majority of bittering components (primarily soft resins) and hop oils no polyphenols no other components	the full range of bittering compounds (soft and hard resins) and the majority of hop oils no polyphenols no other components
Variety characteristics	fingerprint of the used variety	the most important groups of substances for the brewing process are transferred into the product in an almost variety specific composition	the most important groups of substances for the brewing process are transferred into the product in a variety specific composition
Purity	plant protection agents and heavy metals are hardly reduced nitrates are hardly reduced	plant protection agents are partly reduced (polarity dependent) heavy metals reduced up to < 95% nitrates are completely removed	plant protection agents are partly reduced (polarity dependent) heavy metals reduced up to < 90% nitrates are completely removed

linalool!). Thermal dealcoholization thus removes the majority of aroma compounds from the base beer, including fermentation by-products and those introduced from hops.
To reintroduce a more beer-typical aroma to the thermally dealcoholized beer, various options are available. Outside the purity law, flavoring of NABs with a 0.0% alcohol content can be done with hop oils, as these products do not introduce any ethanol. For NABs with an alcohol content of < 0.5% vol., blending with aroma water or typically with mother beer can be carried out.

Table 2: Analysis results of the used hop products in %

	Pellets Type 90	CO_2 - Extract	Total Resin Extract
Lead conductance value	19.6	60.0	51.8
Alpha acids	18.2	58.7	47.4
Iso-alpha acids	-	-	2.0
Conductometric bitter value	-	-	52.8
Polyphenols	4.7	-	-

Experimental Setup and Physical Dealcoholization

To further investigate the sensory differences of the individual hop products on the resulting NABs, another series of experiments was conducted in collaboration with the Chair of Brewing and Beverage Technology (BGT). The equipment at the BGT's technical facility allows the production of experimental beers on an 8 hl scale and their subsequent dealcoholization using current physical methods: thermal dealcoholization and reverse osmosis. The systems themselves, their equipment, and the differences between the methods and the resulting beers have already been presented in the brewing industry [4, 5, 6]. The production of alcohol-free beers using stopped fermentation, cold contact, or the use of specialty yeasts was not investigated in this experimental setup due to the multitude of possibilities.
The research question of this second series of experiments was: Which hop product is best suited for hop addition at the beginning of the boil in the mother beer when producing alcohol-free lager beer using common physical dealcoholization methods?
To account for different country-specific regulations regarding the alcohol content of NABs, NABs with 0.0% residual alcohol were initially produced in all cases, as well as blending with mother beer to produce NABs with an alcohol content of < 0.5% vol.
The three aforementioned hop products, all from the 2021 harvest and the same hop variety (Hallertauer Polaris), were tested. Table 2 shows the main constituents analyzed according to current EBC Analytica methods [7].

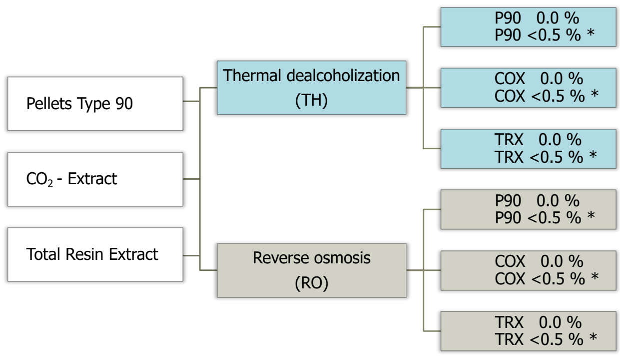

Figure 1: Experimental setup for the production of 12 AFBs

* blended with mother beer

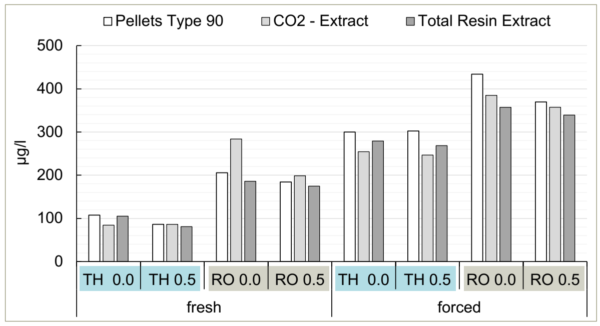

Figure 2: Sum of all aging components of fresh (left) vs. forced (right) beers

Table 3: Analysis results of the mother beers (MB) and the produced 0.0% vol. NABs

	Pellets Type 90			CO_2 - Extract			Total Resin Extract		
	BB	NAB TH	NAB RO	BB	NAB TH	NAB RO	BB	NAB TH	NAB RO
pH-value	4.60	4.56	4.66	4.62	4.61	4.72	4.64	4.59	4.74
Original gravity [% w/w]	12.64	4.55	4.27	12.45	4.76	4.06	12.60	4.76	4.16
Alcohol by volume [%]	5.32	0.01	0.07	5.15	0.01	0.03	5.24	0.01	0.01
Degree of fermentation app. [%]	79.5			78.3			78.7		
Iso-alpha acids [ppm]	16.7	17.6	17.9	15.1	15.7	17.4	14.9	16.9	16.9

Table 4: Ranking of alcohol-free beers based on their respective tasting schemes

	Ranking	Thermal dealcoholization		Reverse osmosis	
Panel # 1	**1**	P90 0.0	TRX 0.5	TRX 0.0	COX 0.5
	2	TRX 0.0	COX 0.5	COX 0.0	TRX 0.5
	3	COX 0.0	P90 0.5	P90 0.0	P90 0.5
Panel # 2	**1**	TRX 0.0	TRX 0.5	TRX 0.0	TRX 0.5
	2	P90 0.0	COX 0.5	P90 0.0	COX 0.5
	3	COX 0.0	P90 0.5	COX 0.0	P90 0.5

Standardized Production of Base Beers

A bottom-fermented lager beer with an original wort of 12.5 °Plato was produced as the mother beer. The hop addition with the respective hop product was carried out exclusively at the beginning of the boil with the aim of achieving 15 - 18 mg/l iso-alpha acid. Fermentation was conducted with yeast strain 34/70, which was freshly propagated from dry yeast and tested for ideal viability and vitality before use. Fermentation, maturation, and storage conditions were identical for each batch. Figure 1 shows the complete experimental setup.

The twelve produced NABs were filled immediately after dealcoholization or blending with mother beer, microbiologically stabilized in a chamber pasteurizer (40 PU), and freshly tasted in the following days. The analysis results of the mother beers are listed in Table 3 in comparison to their corresponding alcohol-free variants (0.0% vol.). The variants cut with mother beer to 0.5% vol. alcohol content (analysis results not shown) differed analytically, if at all, only slightly from the 0.0% vol. NABs and had an alcohol content ranging from 0.40 to 0.48% vol.

Due to the nature of the dealcoholization process, there is an increase in bitterness compounds. This increase was only slight in the thermal method and more noticeable in reverse osmosis.

Sensory evaluation was conducted by trained tasters from the Chair of BGT and Hopsteiner. At the Chair of BGT, all beers were evaluated according to the DLG scheme. At Hopsteiner, the evaluation was based on an in-house tasting scheme that focused on the expressions of bitterness and aroma compounds introduced by hops [8]. Both panels consisted of a number of 10 or 11 consistent participants.

Results

Mother beers produced from different hop products showed almost no analytical differences. Original wort, degree of fermentation, pH values, and other analysis data not listed here were close to each other and corresponded to a typical lager beer or alcohol-free lager beer. The bitter compounds introduced by hops also showed no significant differences.

The tasting results from the respective rankings of the "overall impression" of both panels are summarized in Table 4. It must be emphasized that the evaluations within individual categories, as well as the overall impression of the beers themselves, differed only slightly, sometimes by only tenths of a point. The presented overall assessment is the calculated result of all individual evaluations of the DLG categories "smell," "taste," "fullness," "acidity," and "bitterness," or the related Hopsteiner tasting scheme.

From these sensory evaluation results, the following conclusions can be drawn:

- Tasting panel #1 preferred total hop resin extract in 2 out of 4 approaches. Panel #2 preferred the use of total resin extract in all NABs. Beers that were bittered with total hop resin extract were significantly more often preferred. These NABs were never ranked last within these series.

- One tasting panel (#2) had the same preference for the hop product in both techniques and their respective blends. The other tasting panel (#1) mostly chose the same favorite for each technique of NAB production, blending, and hop product but had different rankings for other aspects.
- NABs produced with pellets were only ranked first in one test approach by one panel. These beers were generally less preferred.
- Compared to pellets, both types of hop extracts showed sensory advantages, especially NABs with total resin extract.
- The preference for hop extract over hop pellets also confirms the results from previous experiments in 2017.

Among the individual categories of the DLG tasting (not listed), the "taste" and "bitterness" of thermally dealcoholized beers, in particular, are noteworthy, giving an advantage to the extract-based beers. Extract beers processed with reverse osmosis showed advantages in "bitterness" and "smell" compared to pellet beers.

Sensory Outlook

To make a statement about taste stability depending on the hop product used and the applied technology, all 12 non-alcoholic beers were aged immediately after production, and the aging components were determined according to method [9]. The sum of analyzed aging indicators is shown in Figure 2.

Although the technique of forced aging cannot replicate the identical results of real-time storage, and sensory impressions do not necessarily correlate with analytical results, the following observations can be made based on the analysis results:

- The sum of aging indicators remained below a total content of 450 µg/l after forced aging. Compared to numerous other internal experiments, the NABs produced here can be classified as fundamentally low.
- The increase in aging components after forced aging was of a similar magnitude regardless of the chosen technique: pellet beers increased by 185 – 228 µg/l, while extract-brewed beers increased by only 101 – 170 µg/l.
- Among all force-aged NABs, the highest concentration of aging components was observed in the pellet-produced variants. Regarding changes during storage, it seems that NABs produced with hop extract are advantageous in direct comparison.
- In terms of alcohol content, the NABs blended with mother beer (0.5% vol. alcohol) were at most on the level of the corresponding 0.0% vol. NABs, but mostly slightly lower. The taste stability of the 0.5% vol. NABs is somewhat better due to the addition of mother beer.

Summary

In this practical series of experiments, the influence of conventional hop products in the brewhouse on the subsequent production of alcohol-free beers was investigated. Different blends (0.0 and <0.5% vol.) as well as physical dealcoholization methods were considered. Both the results of the tastings by two trained panels and the analysis results of forced aging suggest that the use of hop extract brings advantages to the resulting NABs compared to the use of pellets. The use of total resin extract was most frequently preferred sensorially. ←

Literature [1] Strobls Bierradar, Inside Getränkemarkt Magazin (2022), p. 8-9 [2] Internet, statista; https://de.statista.com/outlook/cmo/alkoholische-getraenke/bier/weltweit#volumen (accessed on 18.07.2023) [3] Biendl, M.; Cocuzza, S: Hartharze – Neue Erkenntnisse über eine altbekannte Hopfenfraktion, Hopfenrundschau International (2016/2017), p. 59-68 [4] Müller, M. et al.: Drei Säulen – Thermische Entalkoholisierung an der Technischen Universität München, Brauindustrie (2015), p. 70-73 [5] Müller, M. et al.: Vielfältige Prozesslösungen –vielfältige Produkte - Einfluss der Entalkoholisierungsmethode auf das Profil alkoholfreier Biere, Brauindustrie (2020), p. 22-25 [6] Kienitz, S.: Alkoholfreies Bier mit Umkehrosmose - Möglichkeiten zur Beeinflussung der Bierqualität, Brauindustrie (2021), p. 21-24 [7] Analytica-EBC Methoden: https://dev.brewup.brewersofeurope.eu/ebc-analytica/category/chemical-physical/hops-and-hop-products (accessed on 18.07.2023) [8] Schmidt, C.; Cocuzza, S.: Well-rounded sensory evaluation, Brauwelt International (2014/II), p. 116-118 [9] Lehnhardt, F. et al.: Prediction Power and Accuracy of Forced Ageing-Matching Sensory and Analytical Results for Lager Beer. Brewing Science 2018, 71, p. 39–48

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