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Development of a Tasting Scheme and a New Systematic Evaluation Program for new German Breeding Lines by example of the New German varieties Callista (CI) and Ariana (AN)

With the rise of the craft beer segment in the United States and also in Europe the demand for new hop varieties has risen very fast. For this beer segment brewers are looking for novel flavours to create individual beers. Thus, for new hop varieties beside agronomical properties the focus is on unique and distinct flavour profiles. Pursuing this objective the Hop Research Centre Hüll implemented a new stage gate process to evaluate the flavour potential of new hop breeding lines. During this evaluation process comprehensive pilot brewing trials were conducted to get an impression about the flavours imparted by the most promising breeding lines in different beer styles. This is unique in the hop breeding process worldwide. The first candidates which passed this process were the new cultivars Callista and Ariana released in April 2016. A panel of 40 beer tasters confirmed the differences in hop flavour in various fields of application for these new cultivars. While Callista creates more grapefruit, passion fruit, peach and gooseberry flavours, Ariana imparts geranium, cassis, lemon, and grapefruit into beers.

Descriptors: hop breeding, Callista, Ariana, sensory, flavor description, hop aroma, hop variety testing

1 Introduction

With the rise of the craft beer sector over the last 30 years the beer market and therefore also the demand for hops in general and for specific hop types has changed dramatically. Due to a growing popularity of fruity beer styles (like IPA and Pale Ale) there is an increasing demand for hops that impart unique and distinct flavours to beer. Following this demand the Hop Research Centre Hüll started a new breeding program in 2006 from which Huell Melon, Hallertau Blanc, and Mandarina Bavaria were released in 2012. Based on their fruity, citrusy and exotic flavour, these new breeds did not fit into the classical characterization of bitter and noble/aroma hops and thus, a new category of special flavour hops was created [15]. Although this characterization can be misleading because every hop variety can be used generally in generating individual flavour which can be seen in the hop flavour guides provided by different hop trading companies [14, 21–23]. Along with this new Special Flavour breeding program a 4-stage evaluation process was introduced at the Hop Research Centre Hüll to increase the efficiency and transparency of the selection procedure prior to the release of a new cultivar. Starting with the organoleptic aroma assessment of agronomically promising breeding lines by a panel of specialists from the hop and brewing industry, in the following pre-screening phase breeding lines with interesting aroma expression are being assessed in dry hopping tests. Those hops with fully convincing dry hopping flavour are being grown subsequently on a hectare scale at different locations providing profound information on their agronomic performance and resistances under different conditions. In the final phase, comprehensive standardized brewing trials are being conducted with only few highly advanced selections revealing the bittering potential as well as the whirlpool and dry hopping aroma of these hops.

While until recently breeding material was only provided to interested brewers for individual brews with limited feedback, these newly introduced systematic brewing trials with new breeding lines provide the best possible and most comprehensive information before a planned release as a new cultivar. The flavour properties will be evaluated in different beer styles as well as with different hopping regimes to cover most of the possible fields of application. The first candidates that successfully passed this stage-gate-process [12] were the new German hop cultivars Callista (CI) and Ariana (AN). The results of these first systematic brewing trials will be given in this paper.

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Table 1 Dry hopping regime for the pre-screening trials

	Ale/Lager	Ale/Lager	Ale/Lager	Ale/Lager
Hop-dosage [ml hop oil/hl]	1.6	1.6	8	8
Contact time [weeks]	1	5	1	5

2 Material and methods

2.1 Dry hopping pre-screening trials

The pre-screening tests for hop variety evaluation took place in the Research Brewery Weihenstephan at the TU München Institute of Brewing and Beverage Technology. As base beer for the performed dry hopping experiments, a Lager and an Ale were brewed in 10 hl scale with identical raw materials and processes (100 % pilsner malt; infusion mash, 12 °P). Target bitterness of the base beer was 20 IBU, which was adjusted with a single addition of Herkules CO_2 extract at the beginning of boil. Fermentation temperature of the Lager was 10 °C (yeast strain: TUM 34/70), for the Ale trial 20 °C (yeast strain: Nottingham, dry yeast). After final fermentation, both beers were matured on fermentation temperature to below 0.1 ppm diacetyl and then stored for 3 weeks at 0 °C. The beers did not undergo further processing like stabilization, filtration or pasteurization. Dry hopping was conducted in 50 litre kegs. After dosing hop powder and 3 times purging with CO_2 to displace oxygen, kegs were filled using a hose directly from the tank and then stored at 3 °C according to the required contact time of hops and beer (Tab. 1). By using shortened fittings it could be avoided to carry further hop and other trub particles from the keg into the bottle during bottling. All bottles were stored in a cool place until tasting. The institute showed that reproducible small scale dry hopping trials are possible [25].

2.2 Pilot brewing trials

The two breeding lines which were in experimental field trials were tested in pilot brews. These brews were produced in the 20 hl pilot plant of Bitburger Braugruppe (Bitburg, Germany). The base wort was an all malt wort made from 100 % pale pilsen type malt mashed with a two mash decoction regime. Mash separation was done in a lauter tun and boiling was for 75 min with low pressure boiling and internal calandria. Trub separation was performed in a whirlpool. The hopping regime for the different beers can be seen in table 2. For the beer with a whirlpool addition the first hop addition at the beginning of wort boiling was done with 6.5 g alpha/hl CO_2-extract (variety Herkules). For lager fermentation the bottom fermenting yeast TUM 34/70 fermented at 11 °C, maturating temperature was 11 °C until diacetyl was below 0.1 ppm. The pitching rate for the lagers was 10–15 Mio. cells/ml. Cold storage at –1.5 °C was for 14 days (non-dry hopped beers) and 21 days for the dry hopped ones. For the ale fermentation Nottingham Ale yeast was used at a fermentation and maturation temperature of 20 °C. The pitching rate for the ales was 4–9 Mio. cells/ml. Cold storage time was identical compared to the lager beers. To avoid influences from a prior batch the pitching yeast was freshly harvested from an unhopped fermentation. All beers were bottled unfiltered. For dry hopping the 20 hl brews were divided to 10 hl fermentation batches and after main fermentation the dry hopping was performed in a static way (pellets were suspended in the specific

Table 2 Hopping regime for the pilot trials

		Hop dosage of the breeding line							
Variety	**Brew description**	**KB [g α/hl]**	**WHP [ml oil/hl]**	**dry hopping [ml oil/hl]**	**pellet dosage KB g/hl**	**α dosage WHP g α/hl**	**pellet dosage WHP g/hl**	**pellet dosage dry hopping g/hl**	**α dosage dry hopping g α/hl**
Callista	Callista KB – Lager	8.5			283				
	Callista KB + dry hopping – Lager			3.0				214	6.4
	Callista WHP – Lager		2.0			4.4	146		
	Callista WHP + dry hopping – Lager			3.0				214	6.4
	Callista KB – Ale	8.5			283				
	Callista KB + dry hopping – Ale			3.0				214	6.4
	Callista WHP – Ale		2.0			4.4	146		
	Callista WHP + dry hopping – Ale			3.0				214	6.4
Ariana	Ariana KB – Lager	8.5			89				
	Ariana KB + dry hopping – Lager			3.0				129	12.4
	Ariana WHP – Lager		2.0			8.3	87		
	Ariana WHP + dry hopping – Lager			3.0				129	12.4
	Ariana KB – Ale	8.5			89				
	Ariana KB + dry hopping – Ale			3.0				129	12.4
	Ariana WHP – Ale		2.0			8.3	87		
	Ariana WHP + dry hopping – Ale			3.0				129	12.4

KB = Beginning of wort boiling, WHP = Whirlpool

Intensity Hop Flavor/Aroma

imperceptible → very intense

0 1 2 3 4 **5** 6 7 8 9 **10**

Intensity Hop Flavor/Taste

imperceptible → very intense

0 1 2 3 4 **5** 6 7 8 9 **10**

Flavor impression

imperceptible → very intense

category	single descriptors	0	1	2	3	4	5	6	7	8	9	10
flowery	geranium, rose, lilac, jasmine, lavender, viola, elder flower											
fruity	cassis, blackberry, strawberry, gooseberry, grape, apple, pear, peach, apricot, honeydew melon, banana, plum, pineapple, passionfruit											
citrusy	lemon, lime, grapefruit, orange, tangerine											
green-grassy	green, grassy, hay											
herbal	parsley, lovage, fennel, marjoram, coriander, chamomille, mint											
spicy	clove, pepper, caraway, bay, nutmeg, aniseed											
woody	piney, cedar, oak, tobacco											
others	vanilla, white wine, licorice, white gummi bear, earthy, moldy, sulfury, onion-like, garlic-like Additional flavour, please state and evaluate intensity:											

1) Please tick the perceived flavors

Bitterness Intensity

imperceptible → very intense

0 1 2 3 4 **5** 6 7 8 9 **10**

Bitterness Quality

unbalanced, long aftertaste, broad → very harmonic

0 1 2 3 4 **5** 6 7 8 9 **10**

Overall impression of this variety in this beer style

negative → positive

0 1 2 3 4 **5** 6 7 8 9 **10**

short description/remarks

Fig. 1 Tasting scheme for the evaluation of the hop aroma in beer

beer and added to the vessel) for 21 days. The fermentation until the extract was below 4 % took 3 days for the ale and 6–7 days for the lager beers. It could be observed that fermentation had a delay of 12 h when the hops were added into the whirlpool compared to the brews with no hop addition into the whirlpool. This is in line with the results of *Anderson* et. al. [1] who found a lengthening of fermentation in the presence of hops. It is assumed that the longer fermentation (data not shown) is due to more hop compounds in the whirlpool hopped wort compared to the others.

2.3 Analytics

All mentioned wort and beer analyses were done according to the standards of MEBAK and EBC [17, 26].

3 Results and discussion

3.1 Tasting scheme

To evaluate the brewing quality of breeding lines a new tasting scheme was developed. The aim was to combine several tasting schemes for hoppy beers [2, 3, 19] while keeping it as simple as possible. For this reason, no differentiation distinctions have been made between flavour and taste. The focus was on intensity and quality of the perceived hop aroma in flavour and taste. Moreover, a general aroma description of the beer flavour was expected of the tasters with some examples for the main descriptor groups already set (see Fig. 1). Also the bitterness was rated in quality and intensity. Finally, the taster had to evaluate if this hop variety fitted with the beer style. This is unique for this tasting scheme and essential for the evaluation of the breeding lines to give the right proposal for the use of this hop to the brewers.

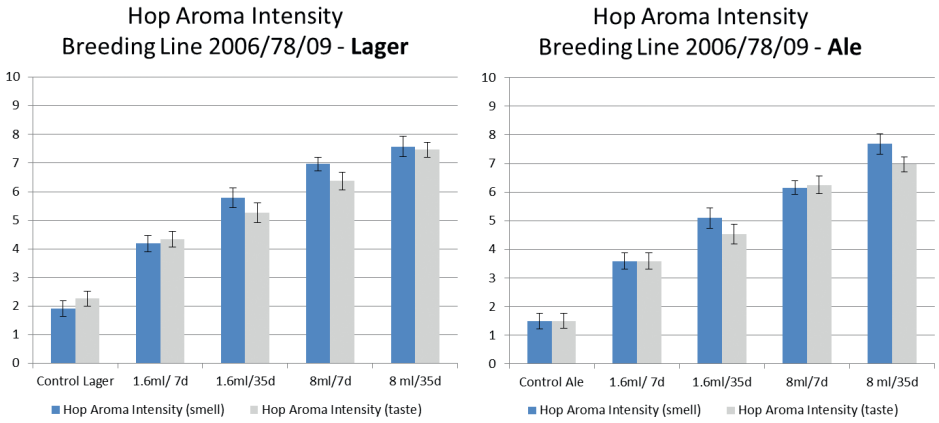

Fig. 2 Breeding line 2006/78/09: hop aroma intensity in beer (pre-screening) depending on dosed hop oil/hl and contact time

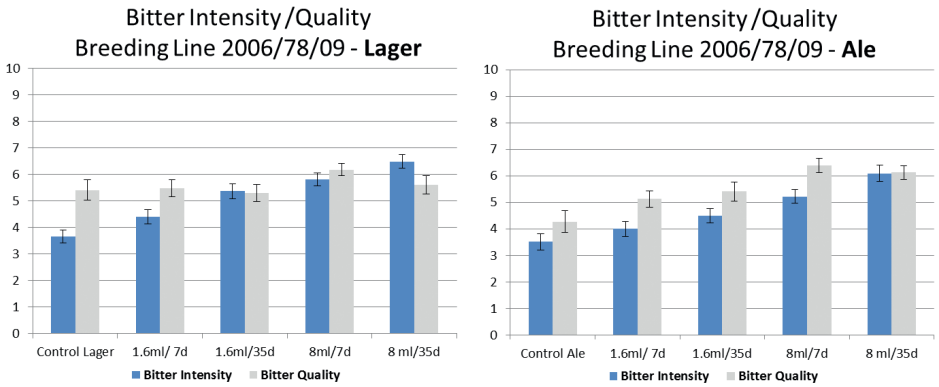

Fig. 3 Breeding line 2006/78/09: bitter intensity and bitter quality in beer (pre-screening) depending on dosed hop oil/hl and contact time

For the tasting a group of 40 persons was acquired. The tasters were trained on beer and used to taste beer but were not exclusively trained for hop flavour perception and description in beer. For the evaluation of the variety specific main descriptors (Tab. 5, see page 101)

Table 3 Analytical data from the pilot scale worts

Wort analysis		Callista			
		KB – Lager	WHP – Lager	KB – Ale	WHP – Ale
Original gravity	%	12.4	12.5	12.4	12.5
pH-value		5.51	5.48	5.53	5.48
Bitterness	EBC	49	59	47	58
Colour	EBC	10.2	9.7	10.1	9.4
Iodine value		0.127	0.126	0.181	0.173
		Ariana			
		KB – Lager	WHP – Lager	KB – Ale	WHP – Ale
Original gravity	%	12.4	12.4	12.5	12.5
pH-value		5.49	5.48	5.49	5.45
Bitterness	EBC	52	77	52	75
Colour	EBC	9.4	9.2	9.5	9.7
Iodine value		0.131	0.106	0.148	0.116

Table 4 Analysis of the final beers

Hop variety		Callista								Ariana							
Beer type		**Lager**	**Lager**	**Lager**	**Lager**	**Ale**	**Ale**	**Ale**	**Ale**	**Lager**	**Lager**	**Lager**	**Lager**	**Ale**	**Ale**	**Ale**	**Ale**
Brew description		**KB**	**KB + dry hopping**	**WHP**	**WHP + dry hopping**	**KB**	**KB + dry hopping**	**WHP**	**WHP + dry hopping**	**KB**	**KB + dry hopping**	**WHP**	**WHP + dry hopping**	**KB**	**KB + dry hopping**	**WHP**	**WHP + dry hopping**
Apparent extract	%mas	2.9	2.8	3.0	3.0	2.4	2.3	2.4	2.3	2.9	2.8	3.1	3.1	2.2	2.2	2.5	2.5
Apparent attenuation degree	%	77.1	77.9	76.6	76.5	81.0	82.1	81.0	81.7	76.9	77.4	75.6	75.6	82.6	82.2	80.5	80.5
Alcohol	%vol	5.2	5.3	5.2	5.2	5.4	5.5	5.4	5.5	5.2	5.2	5.2	5.2	5.6	5.5	5.5	5.5
Original gravity	%mas	12.6	12.7	12.7	12.8	12.5	12.5	12.6	12.6	12.6	12.6	12.8	12.8	12.7	12.6	12.7	12.7
pH-value		4.63	4.67	4.61	4.64	4.37	4.46	4.38	4.39	4.59	4.62	4.65	4.75	4.31	4.43	4.36	4.40
Bitterness	EBC	33	40	39	45	28	31	32	34	40	45	48	50	33	37	38	40
Foam (Nibem)	s	253	251	257	258	234	251	253	259	271	275	250	264	263	277	243	227
Polyphenols	mg/l	278	303	224	242	272	289	223	249	213	212	213	225	212	230	200	223
Anthocyanogens	mg/l	155	166	112	121	166	176	129	137	106	113	106	118	125	126	112	119
Nitrate	mg/l	11.6	13.6	8.4	10.0	9.1	10.9	4.8	7.2	7.8	8.6	8.9	10.1	4.6	6.1	5.3	6.9
trans Iso-Cohumulone	mg/l	2.8	2.5	5.0	4.8	2.4	2.3	4.1	4.0	6.8	6.7	6.8	6.5	5.8	5.7	5.7	5.6
cis Iso-Cohumulone	mg/l	5.5	5.4	9.6	8.9	4.8	4.6	8.3	8.1	14.9	14.4	13.2	12.8	13.0	12.5	11.9	11.7
trans Iso-n-Humulone	mg/l	5.1	4.7	4.8	4.3	3.7	3.6	3.7	3.6	4.7	4.4	5.5	5.2	3.3	3.2	4.2	4.1
cis Iso-n-Humulone	mg/l	12.5	11.5	10.2	9.2	9.7	9.3	8.3	7.9	11.3	10.7	11.4	10.7	8.4	7.9	9.4	9.1
trans Iso-ad-Humulone	mg/l	1.2	1.0	1.1	0.9	0.9	0.8	0.9	0.9	1.2	1.1	1.4	1.3	0.9	0.8	1.1	1.0
cis Iso-ad-Humulone	mg/l	3.6	3.3	2.9	2.6	2.8	2.7	2.4	2.3	3.2	3.0	3.2	3.0	2.4	2.3	2.7	2.6
Iso-Alpha-acids	mg/l	30.6	28.3	33.7	30.6	24.3	23.3	27.7	26.7	42.1	40.2	41.5	39.6	33.8	32.4	34.9	34.2
Alpha-acids	mg/l	1.0	3.6	2.8	4.3	0.4	1.4	1.6	1.8	2.0	5.8	8.2	9.6	0.7	2.9	3.0	3.3
Linalool	µg/l	10	209	101	344	11	130	99	175	3	36	52	106	3	44	62	105
Terpineol	µg/l	6	12	14	24	7	12	11	15	2	4	12	13	3	5	15	15
Geraniol	µg/l	13	14	10	13	10	12	9	9	10	12	9	9	14	12	11	9
Nonanal	µg/l	1.4	1.3	2.2	2.0	1.3	1.5	2.0	2.4	2.5	1.7	1.7	1.4	2.6	1.9	2.0	1.4
Isopentyl acetate	mg/l	0.89	0.78	0.82	0.77	1.39	1.28	1.12	1.06	0.89	0.83	0.64	0.56	1.38	1.24	0.99	0.81
Difference of bitter units	EBC	7		6		3		2		5		2		4		2	
Iso-Alpha-acids difference	mg/l	–2.3		–3.0		–1.0		–1.0		–1.9		–1.9		–1.4		-0.8	
Alpha-acids difference	mg/l	2.6		1.5		1.0		0.2		3.8		1.4		2.2		0.3	

a minimum of 14 tasters (33 % of the taste panel) had to mention this descriptor and multiple descriptors could be given.

3.2 Pre-screening

For product development issues, breweries often use small scale vessels (kegs) [8, 18, 20]. It is known that there can be some variations between small scale compared to industrial scale dry hopping trials, but upscaling is possible if brewery depending factors are known [20, 27]. On basis of this know-how it is feasible for pre-screening a hop variety to use small scale approaches like conducted in these trials. Due to the complexity of the analysis and the so far partly unclear relevance of hop variety dependent components for the later hop aroma in beer, the pre-screening trials were assessed exclusively on a sensory basis. To assure comparability of the results all beers were tasted on the same day under the same conditions. For the pre-screening trials in total four breeding lines were selected from the harvest 2014 and processed in the research brewery Weihenstephan. The main findings of this test series for breeding line 2006/78/09 were as follows:

- Intensity of the hop aroma and bitterness rose with the amount of oil dosed, as well as with the contact time between hops and beer (Fig. 2).
- Bitter quality of trials with 8 ml of oil equivalent/hl deteriorated with prolonged contact time (Fig. 3).
- Differences between bottom and top fermentation were low (Fig. 2; Fig. 3).
- The fruity note of raw hops was perceptible also in the beer (Fig. 5, see next page).

The results of three further tested breeding lines (2009/01/718, 2010/35/13 and 2010/75/764) followed a comparable trend like breeding line 2006/78/09 (data not shown). Due to the large amount of data only the variants with a hop dosage of 8 ml oil equivalent/hl, 5 weeks contact time and bottom fermentation are shown to illustrate the differences observed between the breeding lines. The main findings of this comparison of the 4 tested samples were:

- Despite the hop dosage was based on the oil content of hops, the intensities of the perceived aroma and flavour impressions

varied. The overall impression of the intensity of hop aroma (smell and taste) differed also, but to a lesser extent of approximately one valuation unit (Fig. 4).

- The overall rating- which assessed the subjective overall impression of a variety in the respective beer type showed that 2010/35/13 harmonised well with bottom-fermented beer and intense hopping. In the top fermented approach with 8 ml of oil equivalent/hl and 5 weeks contact time the overall rating of 2006/78/09 and 2010/35/13 was almost identical (data not shown).
- Breeding line 2010/35/13 got the highest rating in the attribute "quality of bitterness" (Fig. 4).
- All tested hop varieties of this series had fruity aroma with more or less distinctive profiles in the dried cones and in the beers. Only 2010/75/764 had a clearly different character with flavours like menthol in hops and spicy or herbaceous flavour in beer (Fig. 5).

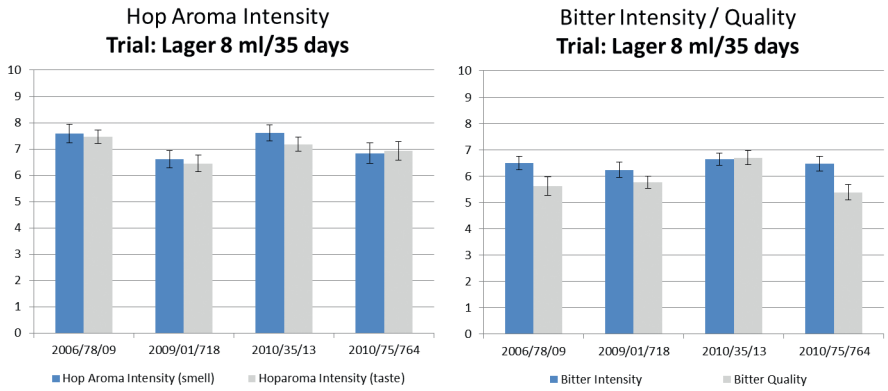

Fig. 4 Hop aroma and bitter impression of all tested breeding lines (pre-screening); hop dosage: 8 ml oil equivalent/hl; contact time: 35 days

3.3 Pilot brewing trials

All worts that were obtained in the pilot brews showed no unexpected analytical data (Tab. 3). Due to the hop addition based on the oil content into the whirlpool the difference in bitterness of the wort between the two varieties was clearly perceptible. An addition according to the oil content was chosen because this procedure could reduce seasonal variations by using batches from different harvests [11, 13]. Due to this the alpha addition in the whirlpool was twice for Ariana compared to Callista (Tab. 2). In table 4 all relevant analytical data to the different beers with the two varieties are shown. It can be seen that the differences in the base properties (original gravity, attenuation degree) were comparable within the specific beer style. Some findings were unexpected: The analytical bitterness level was increased by dry hopping, but the rate of increase was in general lower for the ale beers than for the lagers (see Tab. 4). Dry hopping results in an increase in IBU but caused a loss of Iso-alpha-acids in the final beer compared to the non-dry hopped version. This contradiction was also shown by *Maye* et. al. [16] and could be confirmed in these trials. The increase in linalool during dry hopping was lower in the ale beers than in the lager beers for Callista. These differences did not occur in Ariana beers. In literature it is found that due to the glycosidic activity of the yeast glycosidically bound flavour compounds can be released [4]. Whether Callista possesses such a bound flavour potential has to be focus of deeper research. Table 4 shows that a for isopentyl acetate – a yeast derived flavour compound, a slight concentration decrease was found for the dry hopped samples in all trials. So far, there is no explanation for this observation. The behaviour of terpineol and geraniol is heterogeneous. For the most part an increase of these compounds could be found during dry hopping but not in all cases. *Forster* et. al. [5–7, 9] published recently the behaviour of geraniol during dry hopping. These researchers claimed that the transfer from geraniol from hops to beer during dry hopping is also depended from geranyl acetate and an esterase activity. Because the geranyl acetate content of the hop varieties Ariana and Callista is not known this heterogeneous behaviour could be due to different geranyl acetate contents in the hops. Very interesting is the behaviour of nonanal. Nonanal contributes to a fruity flavour and was found by *Steinhaus* et. al. to be a potent odour-active volatile which was detected by this group mainly in the US variety Cascade [24]. In the Callista beers with hop addition in the whirlpool a slightly

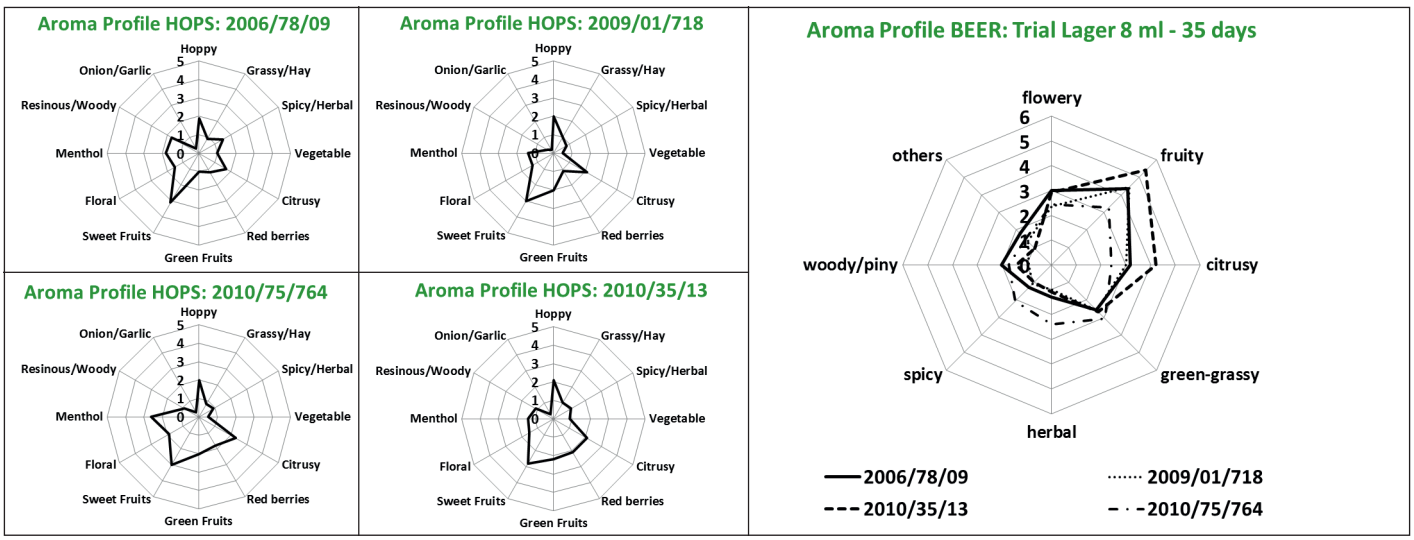

Fig. 5 Hop aroma profile of raw hops and beer; hop dosage: 8 ml oil equivalent/hl; contact time: 35 days

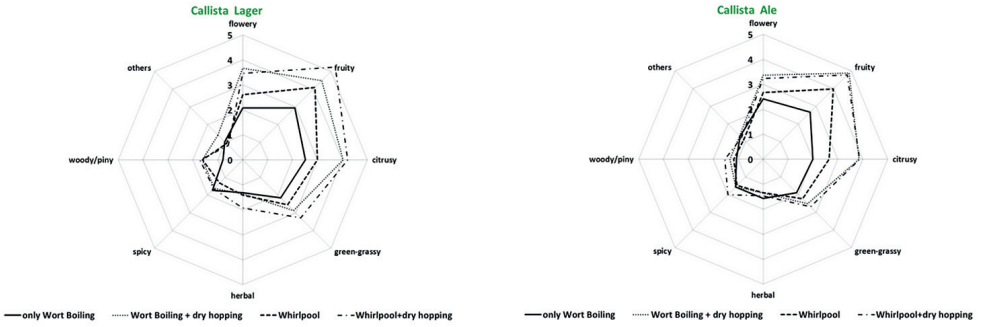

Fig. 6 Descriptive tasting of the beers made with Callista

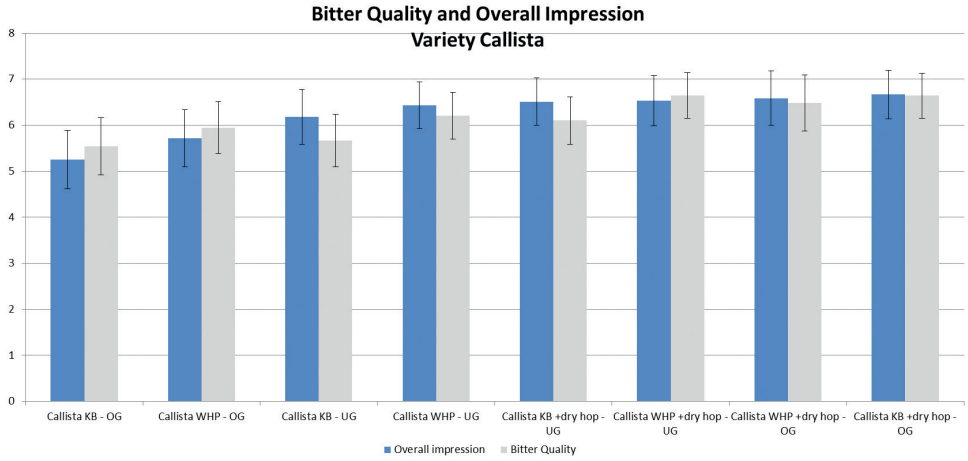

Fig. 7 Bitter quality and overall impression rating of Callista

higher concentration of nonanal could be observed with no influence from dry hopping. For the beers made with Ariana there was not such a pattern. The highest concentration was found in the beer with the single hop addition at the beginning of wort boiling.

Main focus of these trials was the flavour evaluation and flavour impact of the new breeding lines to provide brewers and hop trading companies the most comprehensive information of a newly introduced variety they could get. To cover most of the applications the different beers shown in table 2 were brewed in a 20 hl pilot scale. The final beers were tasted and described as depicted in figure 1.

The lager beers made with Callista showed medium fruity and citrusy notes with also some green grassy components (Fig. 6). A more detailed look to the subdescriptors of the single main categories (like fruity) reveals that Callista, independent from the beer style, contributes to the aroma of beer flavours like passion fruit, grapefruit, gooseberry, peach and some piney notes (Tab. 5). The only difference between the two beer styles could be found for the attribute grapefruit, which was more often mentioned in the bottom fermented beers. The ranking of bitterness quality revealed no big differences between the various beers. It seems that a perceived hop flavour increased the rating for the bitter quality, because the ratings for the beer with the single hop addition at the beginning of wort boiling were at the lower end. The difference was not significant (Fig. 7). The overall impression is an attribute which is new for a hop tasting scheme. The reason for introducing this attribute was to assess whether there were differences in a possible field of application or whether one of the major styles (lager vs ale) fitted better to this variety. Figure 7 demonstrates that the dry hopped samples were rated better than the non dry hopped ones. The ratings showed that Callista could be used in a multitude of beer styles and it fitted well with bottom fermented and also top fermented styles. Since the main beer styles in the US craft brewing scene are top fermented [10] this variety is also suitable for new lager styles.

The Ariana beers showed also fruity peaks in the tasting. Especially the lagers were fruity and citrusy while the dry hopped versions were also noted with green flavours and with some light woody/piney notes, too. Dry hopping increased the fruity impression more than the others. The ales showed the same flavour impression but the intensity was slightly different. Here slightly more citrusy and less green-grassy notes were detected by the tasting panel. (see Fig. 8) The single descriptors for Ariana, predominantly mentioned by the tasting panel, were grapefruit, cassis, gooseberry, geranium, lemon and vanilla. Here also differences between ales and lagers became obvious. The ales had a bit more lemon-like impressions and less grapefruit, so the same pattern as in the Callista trials could be seen. In this context it was also possible so determine the main differences between the two new varieties. Although the main aroma descriptors were almost identical for both varieties, with the single aroma descriptors it was possible to detect peach, passion fruit and some piney notes in the Callista beers while Ariana could contribute cassis, geranium and vanilla notes to the beer (see Tab. 5). The ranking of the bitter quality showed that the top fermented WHP beers had the highest quality rating. The top and bottom fermented KB beers were rated significantly lower in bitter quality than the

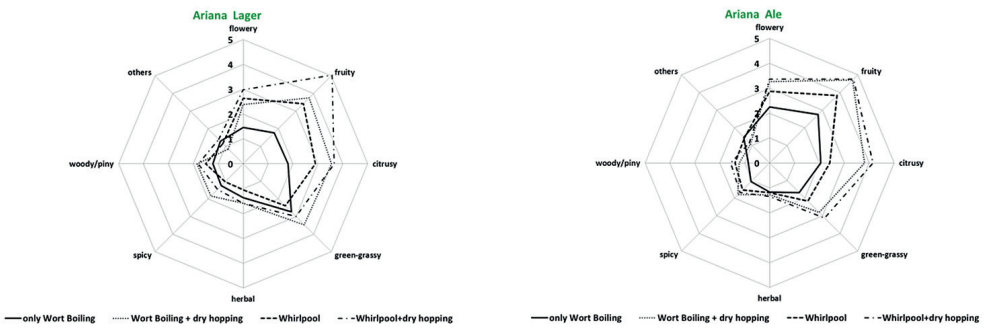

Fig. 8 Descriptive tasting of the beers made with Ariana

WHP ales and also the dry hopped WHP lager beer. Figure 9 shows the rating of the overall impression. Similar as in the Callista trials, the solely at the beginning of wort boiling Ariana hopped beers had the lowest ranking in the overall impression while the lager and ale version of the dry hopped WHP had the highest rating in the overall impression. The variety Ariana showed very good results when used for dry hopping as demonstrated in figure 9. Knowledge like this is essential to the brewer to create harmonic beers with a high drinkability and a good overall impression.

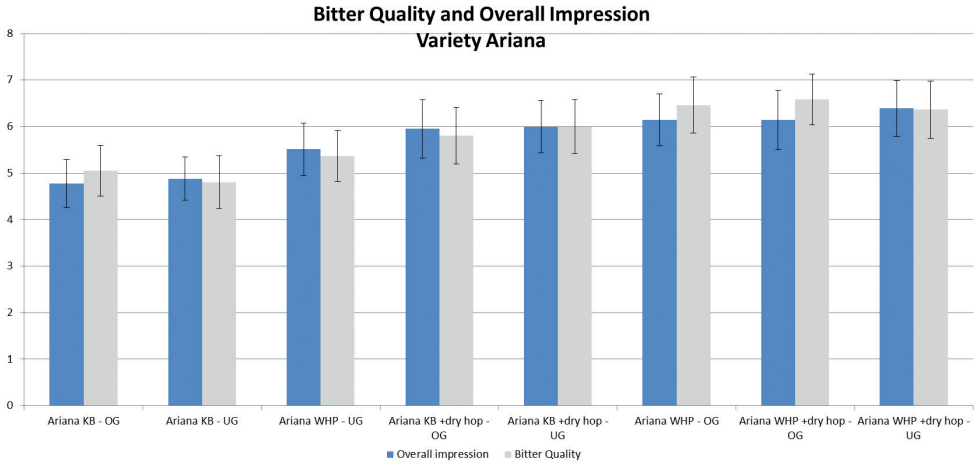

Fig. 9 Overall impressions and bitter quality ranking of Ariana

4 Conclusion

During the last decades the use of hops has changed from only bittering to multi purpose hop use. The hop flavour came into the focus of the craft brewers. Thus, the full flavour potential became also part of the breeding programs worldwide. Hop breeding is a time-consuming procedure therefore it is important to get relevant information for the brewers in an adequate period of time. The presented novel evaluation procedure aims to get a profound knowledge basis from a breeding line before its market release. This know-how helps brewers selecting varieties from the large number of possibilities and finally can make product development more efficient. As a result of the pre-screening trials it can be evaluated what special notes to dry hopped beer a promising candidate from the raw hop evaluation can impart and how much time and hops are needed to create this special note. In the following semi-technical brews the bitter quality as well as the late- and dry- hopping properties are assessed in two different beer styles. After passing the whole 4-stage process, for each breeding line data of at least 2 different harvests is available for the dry hopping trials. On basis of this data some year to year changes might be identified.

All this information is created prior to the release of a variety and serves as an objective and profound base for the decision whether

Table 5 Main descriptors of the beers made with Callista and Ariana

		Percentage of mention of the descriptor in relation to ALL descriptors					
		Callista			Ariana		
		Lager	Ale	independend from beer style	Lager	Ale	independend from beer style
flowery	geranium	3.4	1.9	2.6	4.1	4.2	4.2
	rose	4.1	2.3	3.2	2.5	3.4	2.9
	jasmin				1.6	5.1	3.3
fruity	cassis				4.5	4.2	4.4
	gooseberry	4.5	3.8	4.1	4.1	3.8	4.0
	pear				3.3	2.5	2.9
	peach	4.5	4.2	4.3			
	apricot	3.0	3.4	3.2			
	honey dew melon	3.7	2.6	3.2			
	passion fruit	6.7	6.4	6.6			
citrusy	lemon	2.6	3.4	3.0	2.9	5.1	4.0
	lime	2.6	3.4	3.0			
	grapefruit	7.1	3.8	5.4	7.0	5.5	6.3
herbal	chamomille	2.6	2.6	2.6	3.7	3.4	3.5
woody	piney	3.7	3.0	3.4			
	oak	3.0	2.3	2.6			
others	vanilla	2.6	3.0	2.8	3.7	4.2	4.0
	white wine	2.2	3.4	2.8	2.1	4.2	3.1
	white gummi bear/jelly baby	2.6	2.6	2.6			

a breeding line should become a variety. Differences in the varieties can be detected very clearly by the descriptive tasting. The new developed tasting scheme provides additionally information about the flavour properties depending on the dosed hop quantitiy of a breeding line and also values if there are any restrictions for the usage (e. g. bitter quality)

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