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Amarillo® – a comparison between the growing regions in the USA and German

Comparison | Successful hop varieties are repeatedly moved from one growing region to another to test their potential. The expectation is that they will show similar agronomic and qualitative characteristics to those in the original growing region. This article uses analyses and brewing trials to show how differences between growing regions in the USA and in Germany may affect hop components.

One historical example is the Hallertau Mittelfrüher, which was exported from the Hallertau region to Tettnang and

Spalt as early as the 19th century. Another example is the American variety Cascade, which was introduced to German growing regions at the beginning of the 21st century. The influence of a growing region on the properties of hops, often referred to as “terroir”, has been the subject of scientific research for some time.

For example, comparative studies of Cascade hops from Yakima (Washington) and the Hallertau region for the 2012 and 2013 harvests showed systematic differences: While the linalool and geraniol contents were more pronounced in the US Cascade, some hop esters and polyphenols were higher in the German Cascade [1]. But even within the various growing regions in the United States, the same hop variety can show significant differences due to the different growing conditions [2, 3].

A successful American flavor variety is Amarillo® VGXP01 [4], which has also been grown in significant quantities in Germany since 2016. It was therefore only logical to also examine this variety for differences between the growing regions of the USA and Germany. These comparisons were carried out with hops from the 2017, 2021 and 2023 harvests backed up with trial brews.

It is worth noting that the Amarillo variety in Germany has not shown any specific problems even after eight years of cultivation. The variety produces very good yields and is relatively resistant to typical hop diseases such as powdery mildew, downy mildew, spider mites and hop aphids.

Country-specific differences in the hops

The selected pellets originated from the processing of several representative individual lots from Yakima and the Hallertau. Both Amarillo hops had the typical varietal character with distinct orange and grapefruit notes. The US samples seemed a bit more aggressive, while the German samples were more harmonious.

The bitter substances were analyzed according to ASBC and EBC (conductometric values and HPLC). The differences between the USA and Germany were only due to variations related to the vintage and not to growing conditions.

More interesting were the polyphenols and some aroma substances. Table 1 lists the results for alpha acids, total polyphenols, hop oil, linalool, the sum of the carboxylic acid esters and the thiols 3MH (3-mercaptohexan-1-ol) and 4MMP (4-mercapto-4-methylpentan-2-one).

LEVELS OF ALPHA ACIDS (EBC 7.7), POLYPHENOLS (EBC 7.14), HOP OIL (EBC 7.10) AND RELEVANT AROMA COMPOUNDS

		USA			Germany		
		2017	2021	2023	2017	2021	2023
Alpha acids	% w/w	7.0	6.8	7.7	7.6	7.6	6.6
Polyphenols	% w/w	3.4	3.6	3.5	4.5	4.4	4.5
Hopfenöl	ml/100g	1.25	1.35	1.90	1.20	1.32	1.60
Hop oils	mg/100g	12	15	13	10	12	12
Carboxylic esters	mg/100g	48	54	52	72	83	75
3MH	ng/g	20	21	25	19	19	21
4MMP	ng/g	2.4	2.6	2.6	0.6	0.5	2.2

Table 1

The latter component in particular is highly active in sensory terms, with a threshold value in beer of just 5 to 10 ng/l. The following systematic differences emerge:

- The German Amarillo contains more polyphenols and carboxylic acid esters;
- the differences in the contents of hop oil, linalool and 3MH are negligible;
- in 2017 and 2021, the 4MMP content in the US Amarillo was significantly higher than in the German Amarillo. In 2023, the 4MMP content was also increased for lots from Germany through the targeted use of gas chromatography to determine the optimal harvest time, as is common practice for Amarillo in the USA.

The analytical differences between the samples from the USA and Germany are not significantly greater than the deviations found in some hop varieties produced in different American growing regions [2, 3].

Trial brews in 2017 and 2021

Ales with a targeted bitterness of 30 IBU were brewed with hops from the harvests of 2017 and 2021. Hop oil was added in the form of hop pellets at a dosage rate of 4 ml/hl each for the last hop addition (50% at end of boil, 50% in the whirlpool) and for dry hopping. The analysis data for

the beers that were only late hopped and the data for the additionally dry hopped beers are shown in table 2 in the form of averages for the sake of clarity.

POLYPHENOLS AND SOME AROMA SUBSTANCES IN US AND GERMAN BEERS ...

(average of late hopped and dry hopped beers)

		2017		2021	
		USA	Germany	USA	Germany
Polyphenols	mg/l	245	305	249	286
Linalool	µg/l	335	314	135	109
9 Carboxylic esters	µg/l	208	344	297	420
4MMP	ng/l	15	7	14	7
3MH	ng/l	na	na	40	62

Table 2 na = not analyzed

The general beer analysis values and the bitterness values showed no differences between the US and German beers and are therefore not listed.

In line with the results for hops, the polyphenol values and the values of nine carboxylic acid esters were higher in the German Amarillo beers than in the US beers. In contrast, the levels of 4MMP in the US beers were twice as high as in the German beers.

A sensory comparison conducted by the panel of Hopfenveredlung St. Johann with the results of the DLG and CMA tastings is summarized in table 3.

AVERAGE OF THE SENSORY RESULTS IN DLG POINTS RESP. THE AROMA CHARACTERISTICS IN POINTS ACCORDING TO CMA

	2017		2021	
	USA	Germany	USA	Germany
Body	4.4	4.7	4.3	4.5
Mellowness	3.7	3.8	3.8	3.9
Quality of bitterness	3.7	3.9	3.8	3.8
Fruity	6.05	5.85	5.75	5.25
Flora	2.95	3.10	3.40	3.15
Citrusy	4.65	4.70	4.30	4.70
Hoppy	4.10	4.00	4.30	4.40

Table 3

The sensory differences were marginal. Only in the “fruity” characteristic did the US beers perform slightly better, while the German beers were perceived as being slightly

more full-bodied. The beers from the 2017 harvest could not be significantly distinguished in the three-glass test and preferences were mixed. The beers brewed with hops from the 2021 harvest could mostly be distinguished in the three-glass test, but no clear preferences were apparent.

Trial brews in 2023

Ales were brewed again with a representative selection of hops from the 2023 harvest. In this series of trials, the dosage of the hop pellets used corresponded to 4.3 ml of hop oil at end of boil/whirlpool (50% : 50%) and 6.2 ml of hop oil for dry hopping. Table 4 shows the main beer analysis values.

ANALYSIS OF BEERS BREWED WITH YAKIMA AND HALLERTAU AMARILLO® HOPS

		USA-Amarillo®	Germany-Amarillo®
Original extract	% w/w	13.2	13.2
Polyphenols	mg/l	258	323
Bitterness	IBU	29	30
Linalool	µg/l	344	340
Geraniol	µg/l	287	325
3 Carboxylic esters	µg/l	56	86
4MMP	ng/l	22	18
3MH	ng/l	62	62

Table 4

Relevant differences were found for the polyphenols and three esters, with the values for the German hops being higher than for the US hops. All other values did not differ significantly.

The sensory analysis led to the following observations:

- A total of 60 tasters from three different panels performed the same two-glass test. These were the questions to be answered: 1.) Is there a difference? And 2.) Which beer do you prefer? 54 of the 60 tasters recognized a difference (**significant), of whom 38 preferred the German beer (*significant).
- In the three-glass test with three different panels, 38 out of 56 tasters correctly identified the different samples (*significant). Of these 38 participants, 20 preferred the US Amarillo beer and 18 preferred the German Amarillo beer. With regard to

the quality of the bitterness and aroma, there was no clear preference.
- The three-glass test was repeated with one of the panels (n=18). The distinction was again *significant (14 correct), but in 12 cases the panelists changed their preference from Germany to the United States or vice versa.

Although the analytical differences between the growing regions were not very pronounced, the beers could often be distinguished. The tasters were not fixed in their preference for one or the other growing region; they changed.

Summary

Amarillo, a protected hop variety from the USA, has also been grown in Germany since 2016 and is used primarily for dry hopping. After eight years of cultivation in Germany, Amarillo has proven to be of agronomic interest. It is not very susceptible to disease and the yield is stable in different climates. A comparison between US and German Amarillo hops provided the following findings:

Analytical differences

The analytical differences between the growing regions are not particularly pronounced. The German Amarillo contains more polyphenols and carboxylic acid esters. Differences in hop oil, linalool and 3MH are negligible. The US Amarillo has a higher 4MMP content. By optimizing the harvest times, 4MMP content in German lots could be in- creased.

Trial brews in 2017 and 2021

Ales with 30 bitterness units were brewed with hops from these harvest years. The polyphenol values and the carboxylic acid esters were higher in the German beers, while the 4MMP content was twice as high in the US beers. The sensory differences were marginal. All beers showed a typical Amarillo aroma profile, with US beers being perceived as slightly fruitier and German beers as more full- bodied. The three-glass tests showed no clear preferences.

Trial brews in 2023

Again, ales were brewed. The relevant differences were found in the polyphenols and esters, with higher values in the German beers. Sensory differences were recognized, but without clear preferences for one or the other beer. Repeated tests confirmed the significance of the differences, but the preferences of the tasters changed in some cases from US to Germany or vice versa.

Amarillo grown in Germany is a valuable addition to the variety portfolio, both in terms of agronomy and brewing technology.

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