



Alpha acids content in Czech hops from 2024 harvest – forecasts, reality and trends

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Abstract

The alpha acids content of the 2024 hop crop in the Czech Republic was evaluated using a pre-harvest forecast, a harvest forecast and a reality. The alpha-acids value in the Saaz variety was 2.72% w/w, in the Žatec (2.87% w/w) and Tršice (2.47% w/w) hop growing regions the content was well below the long-term averages, and in the Úštěk region (3.38% w/w) it was in line with the average. In Žatec and Úštěk, the alpha acids of the most widely cultivated hybrid varieties Sládek (7.5 and 6.7% w/w) and Premiant (7.5 and 8.5% w/w) were significantly higher than in Tršice (Sládek 4.8% w/w, Premiant 6.0% w/w). The values of the varieties Saaz Late and Saaz Special were below the average, while Kazbek (6.49% w/w) showed a good tolerance to weather conditions and the alpha acids content slightly above the average. The bitter varieties Agnus, Rubín and Vital with alpha acids content of 11–13% w/w give very stable alpha acids values over the long term, with 2024 corresponding to previous vintages. The harvest forecasts for alpha acids this year were in a very good agreement with reality. The year 2024 was relatively rich in water, but the distribution of rainfall over time was not optimal. Average monthly temperatures during the growing season were 1–2 °C above long-term averages, and the year as a whole was very warm. The Czech Republic's hop harvest (total of 6494 tonnes, yield 1.34 t/ha) was average in 2024. The total alpha acids production from the 2024 harvest was average at 242.5 t. The Saaz hops (82.1 % of the harvested area) accounted for 55% of the total. Bitter hop varieties cope better with adverse weather conditions than aromatic varieties.

Keywords: hops; alpha acids; Saaz hops; hybrid varieties; weather conditions

1 Introduction

The alpha acids content of hops from a particular year is an important piece of information for growers, merchants and brewers every year. In the relationship between the grower and the trader it can influence the purchase price of the hops, and for the brewer it is important in order to secure the quantity of hops needed for the planned beer production. Harvest forecasts of the alpha acids content of hops harvested in the Czech Republic have been made since the

1960s by the Research Institute of Brewing and Malting (RIBM) in Prague (Vančura et al., 1976). At that time only one variety, Saaz (Žatecký poloraný červeňák), was grown. Therefore, a sufficient number of samples was available for the evaluation of the hop crop. The cultivation of other hybrid varieties (Sládek, Bor) was allowed by the government authorities only in 1994. Harvest forecasts of the alpha acids content have been made until today, with the

addition of the main hybrid varieties Sládek and Premiant since 2004, and later the varieties Agnus (2009) and Kazbek (2015) (Mikyška et al., 2021). The actual alpha acids content data from the annual harvest are obtained by processing primary analytical data from several laboratories. The first harvest processed in this way was in 1994 (Krofta and Kroupa, 1995) when, for the first time, a very low alpha acids content well below 3.0% w/w was recorded in Saaz hops. This was caused by a long hot and dry wave at the turn of July and August.

Since the weather has a major influence on the level of alpha acids in all varieties, monitoring of weather parameters (maximum, minimum and mean daily temperatures, rain precipitations, etc.) is part of the evaluation. Data are obtained from a network of weather stations located in all hop-growing regions. The content of alpha acids in Czech hops from annual harvest have been systematically assessed for several decades by the Hop Research Institute (HRI) in Žatec (Saaz) and the Research Institute of Brewing and Malt-ing (RIBM) in Prague with significant participation of the Chmelařství, Cooperative Žatec and VF. HUMULUS Hořesedly.

The alpha acids contents are assessed for all hop growing areas in the Czech Republic, the Žatec (Saaz) region, the Ústěk (Auscha) region and the Tršice (Tirschitz) region in Moravia. As for the harvest parameters (yield, alpha acids content), there may be significant differences among the hop growing regions because the distance between them is about 300 km in a bee line.

The subject of this article is to provide summary information on the alpha acids content of Czech hops in relation to the weather conditions during the growing season. It follows up on previous publications in which the alpha acids content of Czech hops from the 2021–2023 harvest was evaluated (Krofta et al., 2024; Mikyška et al., 2023; Krofta et al., 2022).

2 Materials and methods

2.1 Weather conditions during the vegetation season

The weather related parameters were monitored by a network of meteorological stations (EMS Brno, Czech Republic) operated by the Hop Research Institute in all hop-growing regions of the Czech Republic. The stations at Stekník, Žatec, Ročov, Kněžves, Tuchořice and Petrohrad are in the Žatec hop-growing region, the stations at Brozany and Liběšice are in the Ústěk region and the station at Tršice is in the hop-growing region of the same name. Meteorological data is collected hourly and is available online (CHI Zatec, 2025). The stations record air temperature (maximum, minimum, average), relative humidity, daily rainfall, solar radiation intensity and measure wind strength; some have soil temperature sensors installed at 20 and 50 cm depth.

2.2 Hop samples

Samples for pre-harvest forecast of alpha acids content are taken from the Saaz variety, which is grown on more than 80% of the hop-growing area in the Czech Republic. The sampling sites, which are the same every year, include all the major locations in the Žatec and Ústěk regions (Golden Creek Valley, Woodlands, Rakovník region, Ohře river basin, Polepy marshes and Ústěk region). The first sample is taken 3–4 weeks before the expected start of the harvest, the following at weekly intervals. The cones are always sampled at the same place in the hop garden from 5–10 plants at a height of 3–6 m (Krofta et al., 2024).

The samples for harvest forecasts come from purchase lots of hops, which are analysed for basic quality parameters, moisture, alpha acid content and biological impurities before processing. Harvest forecasts are made for all major varieties, i.e. in addition to Saaz hops, they also include the hybrid varieties Sládek, Premiant, Kazbek, Agnus and possibly others. These samples are collected by the analytical laboratory of the Chmelařství, Cooperative Žatec. They are gradually transferred to the RIBM, where harvest forecasts, differentiated by variety and hop-growing region, are prepared from the analysis of the selected samples.

The actual alpha acids contents are determined by evaluating the analytical data from all the purchase and farm samples of hops. The data are generated by three independent laboratories (HRI Žatec, VF Humulus Hořesedly and Chmelařství Cooperative Žatec). The results are processed by variety and separately for all hop-growing regions (Žatec, Ústěk, Tršice).

2.3 Analytical and statistical assessment

The alpha acids content in all samples was determined by the modified method EBC 7.4 (EBC Analysis Committee, 2025). The modification consists of adjusting the hop weight (7.5 g), the volume of solvent (toluene, 50 ml) and the extraction time (90 min). The whole procedure is part of standard CSN 46-2520, part 15 (ČSN 46-2520). Statistical evaluation of the experimental data was performed with the help of statistical software Statistica 12 (StatSoft, CZ). Mean values were expressed as arithmetic mean and median.

3 Results and discussion

3.1 Weather conditions during the vegetation season of 2024

The year 2024 will be listed as one of the warmest years in the historical survey, similar to the previous year. With the exception of January, the average monthly temperatures were 1–2 °C above the long-term average. The hot-

test months were February, July and August. Precipitation in 2024 was relatively high. About 400 mm of rainfalls fell from April to September, and as much as 460 mm in the Tršice area. However, it was often torrential rain from storms, with several tens of mm falling in a short period of time. Some hop yards were damaged by hail during the growing season. The worst affected area was Radovesice, which was hit by hail on 21 June. The mostly mature and abundantly planted hop crop promised a good harvest. However, optimistic estimates of high yields per hectare were not fully realised at harvest. The average monthly temperatures and rainfall during the growing season (April–September) at selected locations in the hop-growing areas are shown in Table 1 and Table 2.

It cooled down significantly in the second half of April. Numerous morning frosts (down to $-5\text{ }^{\circ}\text{C}$) did not cause serious damage to hops (unlike fruit trees), but delayed the onset of vegetation. The whole of May was rich in rainfall.

The spring work in the hop gardens was completed within the agrotechnical deadlines. Some growers had problems with a high incidence of a hop flea beetle (*Psylliodes attenuatus*), against which they did not have effective remedies. The insecticide Actara was no longer authorised for use in 2024. The first tropical day ($32\text{ }^{\circ}\text{C}$) was recorded in Žatec on 18 June. It was fortunately isolated, as it rained the following day. In July, tropical days and days with high cloud cover alternated. Precipitation was only of a thunderstorm nature and varied locally

Table 1 Average monthly temperatures ($^{\circ}\text{C}$) in the vegetation months in 2024

Month/Locality	Žatec	Stekník	Tuchořice	Kněževes	Ročov	Petrohrad	Brozany	Liběšice	Tršice
April	11.0	11.1	11.4	10.3	10.7	10.7	11.7	10.8	11.8
May	15.6	15.3	15.8	14.6	14.9	15.1	16.4	15.7	16.9
June	19.0	18.6	19.0	18.0	18.0	18.6	19.2	18.5	19.5
July	21.2	21.0	21.2	20.3	20.2	20.8	21.1	20.6	21.9
August	21.5	21.4	21.6	21.0	21.0	21.1	21.6	21.3	22.0
September	15.9	16.3	16.1	15.6	15.8	15.3	17.0	17.0	17.1

Table 2 Monthly precipitation totals (mm) in the vegetation months in 2024

Month/Locality	Žatec	Stekník	Tuchořice	Kněževes	Ročov	Petrohrad	Brozany	Liběšice	Tršice
April	21.6	23.4	21.2	24.2	21.8	23.8	22.6	24.6	46.8
May	89.2	81.2	71.8	26.2	102.6	97.6	109.0	80.8	45.1
June	45.6	54.4	49.0	31.4	54.8	27.2	110.6	41.6	184.5
July	23.6	40.8	34.0	35.2	47.0	24.4	85.2	127.4	28.5
August	103.4	100.8	100.0	75.6	55.6	84.8	49.6	43.6	42.0
September	102.0	106.0	125.8	119.0	143.0	123.6	58.4	84.0	117.7
Total	385.4	406.6	401.8	311.6	424.8	381.4	435.4	402.0	464.6

3.1.1 Žatec and Ústěk regions

The beginning of the year was marked by significant temperature fluctuations. The first warm and rainy week was replaced by a freezing wave from Siberia. Night temperatures plummeted to $-14\text{ }^{\circ}\text{C}$. The last decade of January and the whole of February were rich in precipitation and above-normal temperatures. Throughout the winter, no significant snow cover formed in the lowlands, which would have gradually melted in spring and created a valuable water supply for vegetation. March was abnormally warm and practically without precipitation. The first summer day ($t_{\text{max}} > 25\text{ }^{\circ}\text{C}$) was recorded in the first week of April.

to a large extent. Heavy rains in the range of 30–50 mm fell only at the beginning of August. The tropical week from 12 August to 18 August, in which maximum daily temperatures reached $35\text{ }^{\circ}\text{C}$, ended with a cold front followed by more rainy days.

Some hop growers in the Žatec region started harvesting on August 17, most only during the following week. In the Ústěk region, harvesting started during week 35 (from 26 August). Due to the rainy weather in the second half of August, the health of the crops deteriorated in some locations due to the presence of downy mildew (*Pseudoperonospora humuli*).

3.1.2 Tršice region

In the terms of weather, the hop growing season can be characterised as exceptionally warm and wet. All growing months were warmer than the 20-year average. The average monthly temperature was 2.2 °C higher than the long-term average for these 6 months. Rainfall was 464.6 mm, 124% of normal. Low to freezing night temperatures in the third decade of April slowed hop growth considerably. Early cuttings and even slight damage to the vegetation tops occurred at plantings and at some locations. The subsequent cool start of May also had a negative impact on hop growth, which was reflected in the delayed establishment date. The first appearance of the hop aphid (*Phorodon humuli*) was recorded in the hop fields in the third decade of April, the earliest overflight since 1995. The aphid overflight culminated in the last decade of May.

May 2024 was assessed as warm in temperature (+2.4 °C deviation from normal) and normal in precipitation, as 9 summer days were recorded in the last decade. June was not only warm (+1.5 °C deviation) but also extremely rainy. A total of 184.5 mm of water fell on 20 days, 266 % of the long-term average. As a result, some hop-growing areas were flooded at the end of the month. Six tropical days were recorded in June, with a maximum temperature of 32.2 °C, the first on 19 June. Secondary infection by downy mildew (*Pseudoperonospora humuli*) was more pronounced on the leaves towards the end of the third decade of June.

The summer months of July and August were very warm with a deviation of 2.2 °C and 2.4 °C from the long-term average. There were 9 tropical days in July with a maximum temperature of 34.7 °C and 12 in August with a maximum temperature of 34.7 °C. Only 28.4 mm of water fell in July and 42 mm in August. The abundant rainfall in September (117.7 mm) did not cause the crops to flood as much as in June, but had a negative effect on the harvest of hybrid hop varieties. The extreme weather conditions contributed to a calamitous occurrence of powdery mildew (*Sphaerotheca humuli*) in one location. Although the warmer weather during the growing season favoured the occurrence of the spider mite (*Tetranychus urticae*) there were no major

problems with this pest, with the exception of one site. The products used, the signalling of the occurrence and the alternation of high and low temperatures associated with higher rainfall played a positive role.

3.2 Evaluation of alpha acids content

The alpha acids content of Czech hops from the 2024 harvest was evaluated in nearly 3,000 purchase and farmer's samples of hops. The hops were analysed in the laboratories of the HRI in Žatec, V.F. HUMULUS Hořesedly, Chmelařství, Cooperative Žatec and the RIBM in Prague in the period of August–October 2024.

3.2.1 Saaz variety

The evaluation of the alpha acids content of Saaz hops starts already in the pre-harvest period by monitoring of the selected 20–30 hop gardens during August in the Žatec and Ústěck hop-growing areas. Hop gardens older than 5 years are deliberately selected to minimise the effect of higher alpha acids content due to the remediation of the planting material from viruses and viroids, which would overestimate the forecasts. In older stands, the alpha acids content is mainly influenced by the location and weather conditions during the growing season (Donner et al., 2020).

The alpha acids content in the pre-harvest period 2024 in the Žatec area showed a very slight increase from a level of about 1.4 to 1.6% w/w at the beginning of the month, rising to 2.6 to 2.7% w/w mid-August, but by the time of harvest in the third decade of August the amount of bitter substances had stagnated. Forecasts for the Ústěck area were more favourable. Alpha acids levels rose gradually from 2.1% w/w at the beginning of the month to 2.7–2.8% w/w at harvest. The actual levels, based on analyses of several thousand hop commercial lots were 2.87% w/w for the Žatec area (median 2.74%) and 3.38% w/w for the Ústěck area (median 3.19%). The pre-harvest forecasts proved to be accurate for the Žatec area, while they were underestimated by about 0.30% for the Ústěck area. For the Tršice area, the alpha acids content of Saaz variety was also very low, only 2.47% w/w (median 2.15%). Many

Table 3 Alpha acids content in Saaz variety (% w/w) from the harvest 2024, forecasts and reality

Saaz aroma variety	Statistics	Žatec	Ústěck	Tršice
Pre-harvest forecast	AM	2.61 ± 0.45	2.73 ± 0.52	–
	M	2.66	2.73	–
Harvest forecast	AM	2.72 ± 0.73	3.00 ± 0.48	2.28 ± 0.52
	M	2.62	3.19	2.04
Reality	AM	2.87 ± 0.95	3.38 ± 1.0	2.47 ± 1.00
	M	2.74	3.14	2.15

AM – arithmetic mean; M – median

samples from this area contained less than 2.0% alpha acids. Harvest forecasts were very accurate in all areas. In line with reality, they predicted the highest alpha acids content for the Úštěk region (mean 3.00%, median 3.19%) (Table 3).

For the third year in a row, the alpha acids content of Saaz variety was below or equal to 3% w/w in all hop-growing regions. Whereas in previous years low alpha acids levels were attributed to tropical weather (2022) or above-average yields (2023), in 2024 the cause is not immediately obvious. It was not a completely dry year. In some months there was plenty of water, but there were also drier periods. However, hops can cope with such conditions. A more detailed analysis of the temperature conditions in the hop-growing regions in the period of June–August, i.e. the blooming, cones forming and ripening phases, is given in Table 4.

There were 35 tropical days in Žatec during this period, of which 8 were tropical days from 10 to 17 August. In other cases, there were isolated tropical days alternating with colder ones. At the Liběšice site, there were only 21 tropical days in the same period, and the aforementioned warm period lasted only 3 days (12–14 August). These differences are due to the different altitudes of the two sites. The low alpha content of Saaz variety in 2024 is due to the generally warmer weather, not only in the growing months. According to the Czech Hydrometeorological Institute, 10 months in 2024 were above average compared to the 1991–2020 normal. February was the warmest (+6.1 °C), while the summer months of June–August were on average 1.4–2.3 °C warmer. The average monthly temperatures in 2024 in Žatec and their comparison with the long-term averages (1981–2010) are shown in Figure 1.

Table 4 Characteristics of tropical days in selected hop-growing locations in 2024

Locality	Žatec			Liběšice			Tršice		
	June	July	August	June	July	August	June	July	August
Tropical days*	5	14	16	2	8	11	6	9	12
Tropical nights**	0	0	0	0	0	0	0	0	0
Tropical periods***	26.–29./4 d $t_{\max}=33,6\text{ °C}$	9.–11./3 d $t_{\max}=35,8\text{ °C}$	10.–17./8 d $t_{\max}=35,1\text{ °C}$	–	–	12.–14./3 d $t_{\max}=33,9\text{ °C}$	–	9.–11./3 d $t_{\max}=34,7\text{ °C}$	11.–17./7 d $t_{\max}=34,8\text{ °C}$
	–	–	29.–31./3 d $t_{\max}=35,3\text{ °C}$	–	–	28.–30./3 d $t_{\max}=33,2\text{ °C}$	–	–	28.–30./3 d $t_{\max}=34,5\text{ °C}$

d= day; * $t_{\max} > 30\text{ °C}$; ** $t_{\min} > 20\text{ °C}$; *** $t_{\max} > 30\text{ °C}$ for 3 or more consecutive days (d)

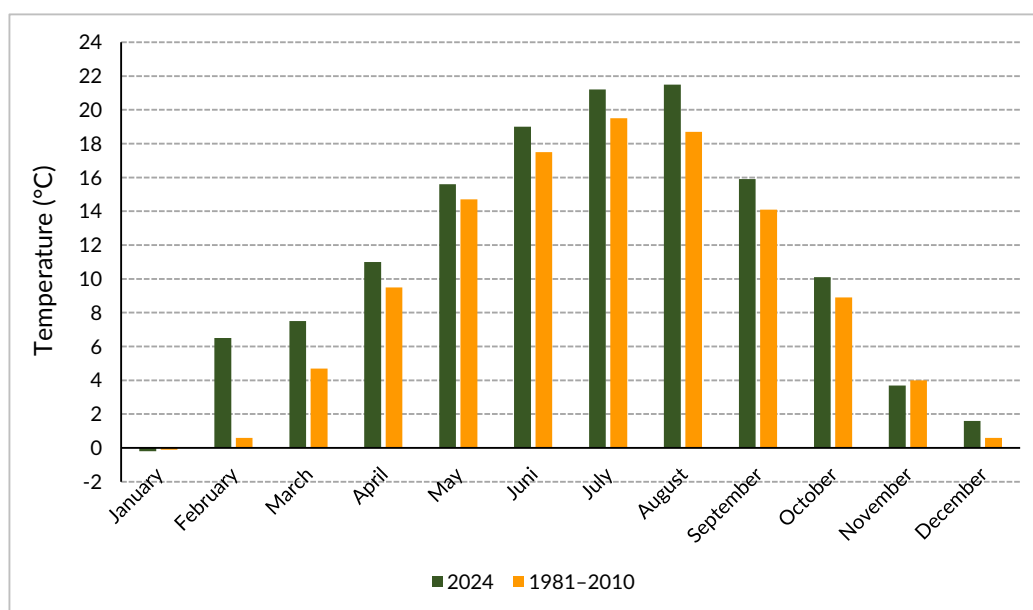


Figure 1 Average monthly temperatures in Žatec in 2024 and comparison with long-term averages 1981–2010

The distribution of alpha acids in the Žatec and Úštěk hop-growing areas is shown in Figures 2 and 3. In both areas the values are divided into two levels, below 3.0 and above or equals 3.0. In the Žatec area, hops from the “Golden Creek Valley” (Siřem, Kryry, Vroutek, Černčice, Liběšovice, Běsno, Velká Černoc, Očihov, Blšany) traditionally had the highest alpha acids content above 3.0% w/w. In the Rakovník region, hops from Kněževes, Chrást’any and Přílepy had a comparable alpha acids content. In the other localities the alpha acids content is mostly in the range of 2.5–3.0% w/w, but in many places the content is below 2.0% w/w (Hořovičky, Krupá, Konětopy, Hokov, Třeskonice, Lipenec, Divice, etc.).

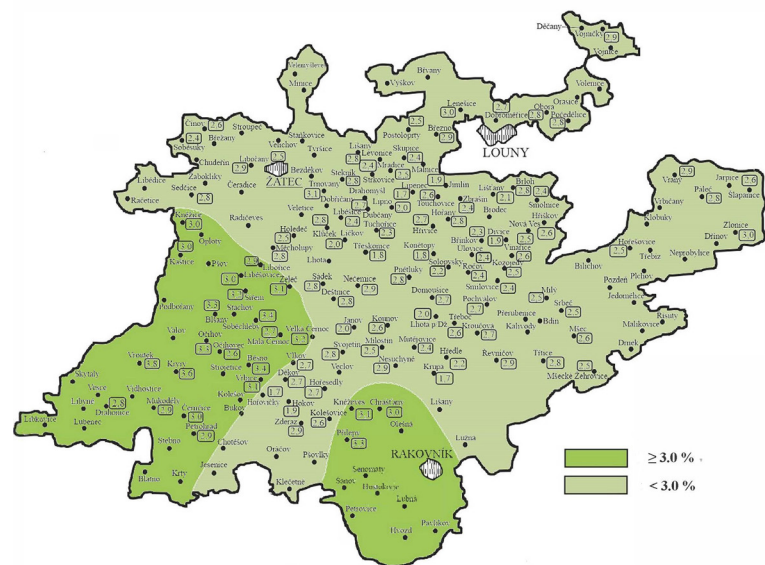


Figure 2 Distribution of alpha acids levels in Saaz hops in the Žatec growing region in 2024

In the Úštěk area, the distribution of alpha acids values is different from most previous years. In 2024, hops from sites in a wider belt in the Ohře and Elbe basins (Brozany, Siřejovice, Kyškovice, Záluží, Lounky, Libotenice, Vědomice, Okna) contained the highest levels of alpha acids above 3.0% w/w. In most of the other sites the alpha acids content was in the range of 2.5–3.0%. In the region of higher altitudes above 300 m in the northern part of the area (Úštěk, Blíževedly, Lukov, Liběšice, Habřina), where alpha acids levels are usually highest, the values were in a relatively wide range of 2.3–3.6% w/w. The lowest amounts of 2.3% were found in Soběnice and Chotiněves. The white area on the zoning map marks the places where hop cultivation was stopped several years ago (probably permanently).

Regular replanting is an important stabilising factor in hop production. New plantations are established with seedlings that have been freed from economically harmful viruses and viroids by biotechnological methods (Fric et al., 1995). Hops from new Saaz variety plantations labelled VT, VF, meaning virus tested and virus free, contained significantly more alpha acids (5.0 to 7.0% w/w) than older plantations. However, due to re-infection with a latent hop viroid (HLVd), these hops undergo a performance

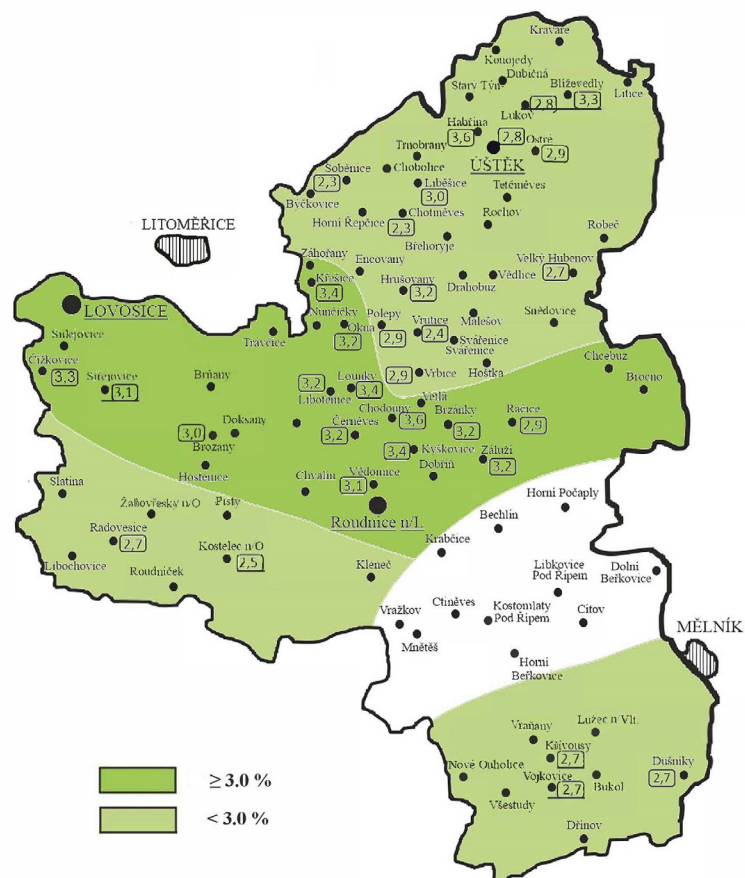


Figure 3 Distribution of alpha acids levels in Saaz hops in the Úštěk growing region in 2024

depression which is manifested by a significant decrease in alpha acids content within 5 years of planting (Patzak et al., 2021; Krofta, 2002). For this reason, the alpha acids

content of Saaz variety varies over a very wide range depending on the location and age of the stand. The lower limit in 2024 was in the range of 2.0–2.5% w/w.

The median values of the actual alpha acids content of Saaz variety shown in Table 3 and the final data on the quantity of hops harvested published by the Central Institute for Supervising and Testing in Agriculture (CISTA, 2025) in December 2024 were used to calculate the total alpha acids production in the Czech Republic.

3.2.2 Czech hybrid varieties

The major Czech hybrid varieties with a growing area of over 20 ha currently include Sládek, Premiant, Agnus, Kazbek, Saaz Late and Saaz Special. Their cultivation is

gradually spreading to all hop-growing regions of the Czech Republic, although the area under cultivation of some of them is stagnating (Saaz Late, Kazbek). Among the new aromatic hops, Saaz Shine is the variety with the largest increase in area under cultivation and the hop gardens are currently concentrated in the Žatec area (Stekník, Chrást'any, Holedeč, Nesuchyně, Staňkovice). In those localities this variety contained 3.3 ± 0.30 % alpha acids. The alpha acids contents of the other hybrid varieties from the 2024 harvest are shown in Table 5.

The Sládek variety contained on average 7.5 % w/w alpha acids in the Žatec area, 6.7 % w/w in the Ústěk area, but only 4.8 % w/w in the Tršice area. The Premiant variety contained on average 7.5 % w/w alpha acids in the

Table 5 Alpha acids content (% w/w), Czech hybrid varieties from the 2024 crop harvest, forecast and reality

Variety/Region		Statistics	Žatec	Ústěk	Tršice
Sládek	harvest forecast	AM	7.44±1.80	6.03±2.04	5.14 ± 0.15
		M	7.74	6.56	5.25
	reality	AM	7.51 ± 1.67	6.74 ± 1.51	4.78 ± 0.59
		M	7.08	6.58	4.64
Premiant	harvest forecast	AM	7.94 ± 1.31	7.08 ± 0.54	5.74 ± 0.98
		M	7.74	7.32	5.22
	reality	AM	7.47 ± 1.17	8.46 ± 1.20	5.98 ± 0.91
		M	7.51	8.24	5.76
Agnus	harvest forecast	AM	11.27± 2.03	-	-
		M	12.24	-	-
	reality	AM	11.97 ± 1.05	12.67 ± 1.06	10.06 ± 0.94
		M	11.90	12.63	10.42
Kazbek	harvest forecast	AM	-	6.67 ± 0.44	5.44 ± 0.16
		M	-	6.95	5.49
	reality	AM	6.14 ± 0.72	7.25 ± 0.62	5.97 ± 0.31
		M	6.31	7.24	5.91
Saaz Late	harvest forecast	AM	3.39 ± 0.20	-	-
		M	3.51	-	-
	reality	AM	2.84 ± 0.52	-	2.29
		M	2.73	-	2.29
Saaz Special	reality	AM	4.99 ± 1.17	-	-
		M	4.72	-	-
Saaz Shine	reality	AM	3.46 ± 0.95	-	-
		M	3.29	-	-
Harmonie	reality	AM	6.32 ± 0.38	-	-
		M	6.48	-	-
Vital	reality	AM	11.77 ± 1.62	12.65	-
		M	12.25	12.65	-
Rubín	reality	AM	12.47 ± 1.42	-	-
		M	12.49	-	-

AM – arithmetic mean; M – median

Žatec area, 8.5 % w/w in the Úštěk area, The lower alpha acids content of hops from the Tršice area was caused by unfavourable weather conditions. The above-average rainfall in June (184.5 mm) caused flooding of hop gardens in many places, which was not good for the plants. Another consequence was the development of diseases and pests, sometimes even calamitous. The waterlogged terrain did not allow protective measures to be taken at the optimum times.

A slightly higher alpha acids content than in the previous year was found in the Saaz Special variety in the Žatec area, with an average of 5.0% w/w. On the other hand, the Kazbek variety contained a somewhat surprisingly high amount of alpha acids (6–7% w/w). Above-average temperatures are also responsible for the low alpha acids content of Saaz Late, which reacts negatively to such conditions (Mikyška et al., 2013). High stability of alpha acids content, practically independent of weather conditions, was confirmed by bitter varieties Agnus, Rubín and Vital (Krofta et al., 2024; Mikyška et al., 2021). The alpha acids content in the range of 10–13% w/w was approximately at the level of previous years.

The harvest forecasts of alpha acids content in the hybrid varieties (Table 6) agree reasonably well with reality, with the exception of the variety Premiant in the Úštěk region, for which the forecast underestimated the median values by about 1.0% w/w. The reason for this is probably the limited number of samples available, which did not cover the whole range of real values. Newly planted hopyards of Sládek and Premiant varieties contained 9–12% alpha acids, which is higher than the typical values reported in the Atlas of Czech Varieties (Sládek 4.5–9.0%, Premiant 6.0–11.0%) (Nesvadba et al., 2022). Unfortunately, even hybrid varieties show performance depression after a few years, similar to the Saaz variety (Donner et al., 2020).

3.2.3 Production of alpha acids in the Czech Republic in 2024

The annual production of alpha acids in the Czech Republic has been calculated from the final harvest balance published by CISTA (2025) at the end of 2024 and from the average alpha acids contents shown in Tables 3 and 5. The results differentiated by variety and growing area are summarised in Table 6. The total production includes the contributions of minor varieties (Vital, Harmonie, Rubín), which are grown on a total area of 29.6 ha. For the hops classified as ‘other’ (Bohemie, Magnum, Most, Perle, Country, etc.), the average content of the alpha acid production was determined as 8 % w/w.

The total production of alpha acids in Czech hops from the 2024 harvest was 242.5 tons and in a longer-term comparison it is among the average ones. The Saaz variety accounts for only 55% of total production, although it is grown on 82.1% of the harvested area. In 2024, this is due to the very low alpha acids content in the Žatec and Tršice area, and the low hectare yield in Tršice. The balance was partly improved by above average yields of 1.28 t/ha in the Žatec and 1.24 t/ha in the Úštěk areas. The volume of production damaged by extreme weather events was not significant in 2024, and some stands have partially regenerated after damage.

3.2.4 Long-term development of alpha acids in Saaz hops in the period 1992–2024

The average harvest values of alpha acids content of Saaz variety during 1992–2024 are shown in Figure 4. It is clear that the levels are very low for the third year, below 3.0% w/w. This has never happened in the past. Similarly low levels were observed in 1994, 2006, 2015,

Table 6 Production of alpha acids (tons) in the Czech Republic in 2024 (CISTA, 2025)

Variety/Region	Žatec	Úštěk	Tršice	Total
Saaz	108.55	14.76	11.36	134.67
Sládek	41.81	8.47	5.11	55.39
Premiant	16.91	5.21	3.55	25.67
Agnus	11.26	2.76	0.32	14.34
Saaz Late	1.68	-	0.06	1.74
Saaz Shine	0.22	-	-	-
Saaz Special	2.79	-	-	2.79
Kazbek	1.98	0.80	0.28	3.06
Vital	0.38	0.24	-	0.62
Harmonie	1.14	-	-	1.14
Rubín	0.21	-	-	0.21
Others	2.61	-	-	2.61
Total	189.54	32.24	20.68	242.5

and 2018. Back then, these were isolated fluctuations caused by long hot and dry waves during the flowering, cones forming and ripening of hops. The year 2024 was different in that there was no hot and dry period during the critical period, but average temperatures during the growing months were consistently 1.0–2.5 °C above long-term values. The increasing frequency of low alpha acids in the Saaz variety occurs probably due to climate changes, which are not favourable to aroma varieties.

From the overview of the average alpha acids levels of major varieties in the Czech Republic in the last 5 years (Table 7) it is clear that the greatest dependence on the weather is shown by the fine aroma varieties Saaz and Saaz Late (relative standard deviation 20%), more stable values at the level of RSD = 8.5–9.5% are provided by hybrid aroma varieties (Sládek, Premiant, Kazbek) and the smallest variability (RSD=4.3%)

has the bitter variety Agnus. This finding is supported by the fact that foreign aromatic varieties Hersbrucker, Saphir, Celeia, Savinjski Golding and Lubliner also had very low alpha acids contents in 2024 (Table 8). The author

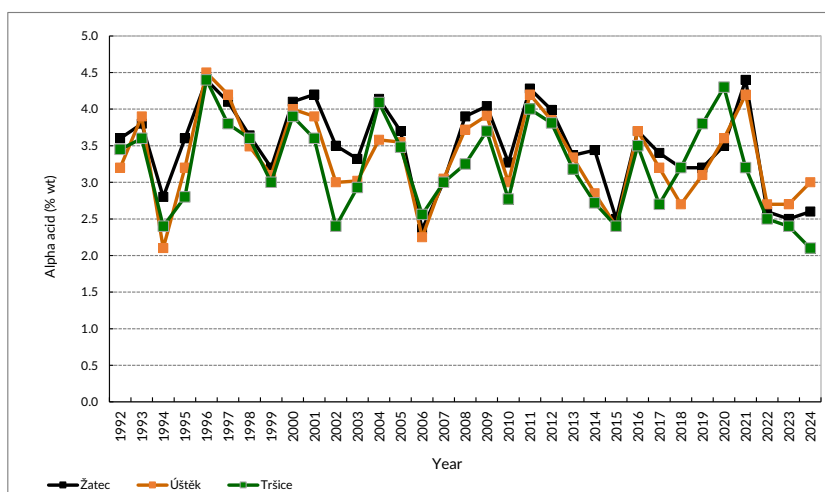


Figure 4 Alpha acids content of Saaz hops in the period 1992–2024

Table 7 Average alpha acids contents of major Czech hop varieties in the Czech Republic (% w/w)

Year/Variety	Saaz	Sládek	Premiant	Agnus	Kazbek	Saaz Late
2020	3.80	7.23	8.39	12.99	6.15	3.07
2021	4.19	8.05	8.82	11.52	6.71	4.40
2022	2.83	6.34	8.25	12.57	6.26	2.52
2023	2.61	6.28	7.18	11.85	5.18	3.42
2024	2.72	6.68	7.33	11.99	6.49	2.71
5 year mean	3.23	6.92	7.99	12.18	6.16	3.22

(Anonymous, 2024) concludes that high alpha varieties (Polaris, Herkules, Magnum) are able to cope with stressful conditions (limited access to water and high temperatures) better than most of aroma hops.

Table 8 Alpha acids content (% w/w) in selected German (G), Slovenian (S) and Polish (P) hops in 2021–2024 (Anonymous, 2024)

Variety/Region	2021	2022	2023	2024	5year mean	10year mean
Hersbrucker (G)	4.6	1.9	3.0	2.5	3.1	2.7
Saphir (G)	4.3	2.6	3.1	3.2	3.5	3.4
Perle (G)	9.0	4.9	6.0	6.2	6.8	6.7
Spalter Select (G)	6.4	3.3	4.7	3.9	4.8	4.5
Hall. Tradition (G)	6.1	5.2	4.9	5.3	5.6	5.6
Magnum (G)	16.0	12.2	11.8	12.9	13.3	13.1
Herkules (G)	18.5	15.4	13.9	15.8	16.1	16.1
Polaris (G)	21.5	18.5	18.0	19.8	19.6	19.5
Aurora (S)	6.8	7.0	9.7	7.7	8.5	8.6
Savinjski Golding (S)	2.2	2.4	3.1	2.3	3.1	3.0
Celeia (S)	3.3	2.6	4.1	3.1	3.5	3.4
Lubliner (P)	3.5	3.9	3.2	2.5	4.0	3.4
Marynka (P)	7.5	8.2	7.8	7.6	8.0	8.1

G – Germany; S – Slovenia; P – Poland

4 Conclusion

The alpha acids content of Saaz, the dominant variety in the Czech hop production, was well below 3.0% w/w in 2024. Pre-harvest and harvest forecasts already indicated this. The harvest in 2024 was similar to the two previous years, while the 2020 and especially 2021 harvests were above average in terms of alpha acids content. The long-term development of alpha acids content in Saaz hops in the period 1992–2023 is characterized by significant interannual fluctuations as a response to the weather conditions of the given growing season. The results of recent years indicate a higher frequency of low alpha acids, probably due to rising temperatures. The fine aroma varieties Saaz and Saaz Late show a strong dependence of alpha acids levels on the weather conditions in a given year, while the bitter varieties Agnus, Vital, Rubín and the aromatic variety Kazbek are fairly resistant to weather fluctuations.

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6 References

- Anonymous (2024). Alpha-säurenwerte von Hopfen der Ernte 2024 und aktualisierte mehrjährige Durchschnittswerte. *Brauwelt*, 125, 935.
- CHI Zatec [online]. Retrieved from http://www.chizatec.cz/?utm_source=search.seznam.cz&utm_medium=ppd&utm_content=hledani&utm_term=chmela%20c5%99sk%20c3%bd%20institut%20c5%beatec&utm_campaign=firmy.cz-257689 [Accessed March 24, 2025]
- CISTA [online]. Retrieved from <https://ukzuz.gov.cz/public/portal/ukzuz/tiskovy-servis/tiskove-zpravy/letosni-sklizen-chmele-se-ra-di-k-tem-prumernym> [Accessed March 24, 2025]
- ČSN 46-2520-15 (1997). Česká technická norma (Czech technical standard). Zkoušení chmele. Část 15: Stanovení konduktometrické hodnoty chmele. Český normalizační institut. (Available Only in Czech)
- Donner, P., Pokorný, J., Ježek, J., Krofta, K., Patzak, J., Pulkrábek, J. (2020). Influence of weather conditions, irrigation and plant age on yield and alpha-acids content of Czech hop (*Humulus lupulus* L.) cultivars. *Plant Soil and Environment*, 66(1), 31–46. <https://doi.org/10.17221/627/2019-PSE>
- EBC-Analytica. European Brewery Convention [online]. Retrieved from <https://brewup.eu/ebc-analytica/search> [Accessed March 24, 2025]
- Fric, V., Krofta, K., Svoboda, P., Kopecký, J. (1997). The evaluation of the virus-free hop quality after five years growing in the Czech Republic. *Rostlinná výroba*, 43(7), 307–314.
- Krofta, K. (2002). Content and composition of hop resins of Saaz hops from the point of view of their brewing value. Ph.D. Thesis, University of Chemistry and Technology, Prague. (Available Only in Czech)
- Krofta, K., Fritschová, G., Mikyška, A., Belešová, K., Vojtěchová, D., Tichá, J. (2024). Alpha acids content in Czech hops from harvest 2023 – forecasts, reality and trends. *Kvasny prumysl*, 70(1), 564–571. <https://doi.org/10.18832/kp2022.68.564>
- Krofta, K., Fritschová, G., Mikyška, A., Belešová, K., Vojtěchová, D., Tichá, J. (2022). Alpha acids content in Czech hops from harvest 2021 – forecasts, reality and trends. *Kvasny prumysl*, 68(1), 564–571. <https://doi.org/10.18832/kp2021.67.564>
- Krofta, K., Kroupa, F. (1995). Hodnocení analytických parametrů chmele v roce 1994 (Evaluation of hop analytical parameters in 1994). *Chmelařství*, 58, 52–54. (Available Only in Czech)
- Kršková, I. (2024). Sklizeň chmele byla v roce 2024 průměrná (The hop harvest was average in 2024). *Chmelařství*, 96(11–12), 120–121. (Available Only in Czech)
- Mikyška, A., Belešová, K., Tichá, J. (2021). Analysis and prognosis of bitter acids content in Czech hop varieties – year 2020 and long-term comparisons and trends. *Kvasny prumysl*, 67(4), 474–483. <https://doi.org/10.18832/kp2021.67.474>
- Mikyška, A., Krofta, K., Fritschová, G., Belešová, K., Kroupa, K., Tichá, J. (2023). Alpha acids content in Czech hops from harvest 2022 – forecasts, reality and trends. *Kvasny prumysl*, 69, 692–699. <https://doi.org/10.18832/kp2023.69.692>
- Mikyška, A., Slabý, M., Jurková, M., Krofta, K., Patuzak, J., Nesvadba, V. (2013). Saaz Late – The Czech Hop Variety Recommended for Czech Beer. *Kvasny prumysl*, 59(10–11), 296–305. <https://doi.org/10.18832/kp2013031>
- Nesvadba, V., Krofta, K., Patzak, J. (2022). Czech hop varieties. Chmelařský institut, Žatec. ISBN 978-80-86836-60-7
- Patzak, J., Hencychová, A., Krofta, K., Svoboda, P., Malířová, I. (2021). The influence of Hop Latent Viroid (HLVd) Infection on Gene Expression and Secondary metabolite Contents in Hop (*Humulus lupulus* L.) Glandular Trichomes. *Plants*, 10, 2297. <https://doi.org/10.3390/plants10112297>
- Vančura, M., Kubíček, J., Loos, J. (1976). Pivovarská hodnota chmelů ze sklizně 1975 (Brewing value of hops from the 1975 harvest). *Chmelařství*, 49, 52–54. (Available Only in Czech)