Drying of hop

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Abstract: In the Czech Republic, belt kilns are predominantly used for hop drying. As in the world other types of hop kilns, such as box kilns, are also frequently used, the comparison appears desirable between the efficiency and quality of the technological processes in the individual kiln types. The present work is aimed at determining the hop drying parameters in the belt hop kiln, and their optimisation.

Keywords: hop; drying; belt hop kiln; qualitative parameters

The aim of the technological process of the hop drying and the subsequent post-harvest treatment is to achieve a high quality product whose brewing value is negatively affected as little as possible by storage and further processing. The brewing value depends qualitatively on the contents of α- and β-bitter acids, the hop conductometric value. In the Czech Republic, belt hop kilns are predominantly used (Rybáček *et al*. 1980). If their old age is not taken into account, it is still necessary to investigate if the current process of drying in the belt kiln with overdrying to the water content of 5–7% and subsequent conditioning is optimal in view value, of the short- and long term storage, preservation of the hop brewing value, and energy requirements.

The measurements were carried out in 2004 in the belt hop kiln PSCH-325 which is used in the Specific Farmsteading Stekník.

The process of hop drying in the belt kiln was overviewed by Neubauer *et al*. (1989), and the results of the measurements obtained with the belt hop kiln were presented by Rybka *et al*. (2006).

MATERIAL AND METHODS

Goal

Evaluation of qualitative parameters of hop dried in the belt hop kiln and their optimalisation:

The qualitative parameters determined by the Hop Research Institute Žatec in agreement with the currently used methods are:

– α bitter acids content as determined by spectrophotometric metod according to ASB
– β bitter acids content
– *HSI* (hop storage index) value
– conductometric value of hop determined by the metod given in ČSN 462520-13 (1997)
– water content in the processed hop samples.

All qualitative parameters influence the hop quality. α and β bitter acids affect the hop taste while *HSI* together with the water content influence the hop storage. Their balance is needed as well as the maintenance of the respective values is the range given for the individual hop varieties.

Material

– The hop variety "Saaz semi-early red bine hop" from the hop garden of the Specific Farmsteading Stekník of the Hop Research Institute Žatec, Ltd., Žatec.
– The hop belt kiln PSCH-325 (Figure 1).
– Weighed aluminium trays for hop samples taking and subsequent drying in the laboratory kiln; laboratory kiln, laboratory scales.
– Sachets for the hop samples destined for the laboratory treatment.
– A notebook with OS MS Windows Millenium and MS Office 2000 and note sheets used for the data entry and their treatment.

Methods

Sampling for the follow-up of the daily dependancies of the hop water content on the drying time

From each of the access windows 1 to 9 in the PSCH-325, three hop samples were randomly taken

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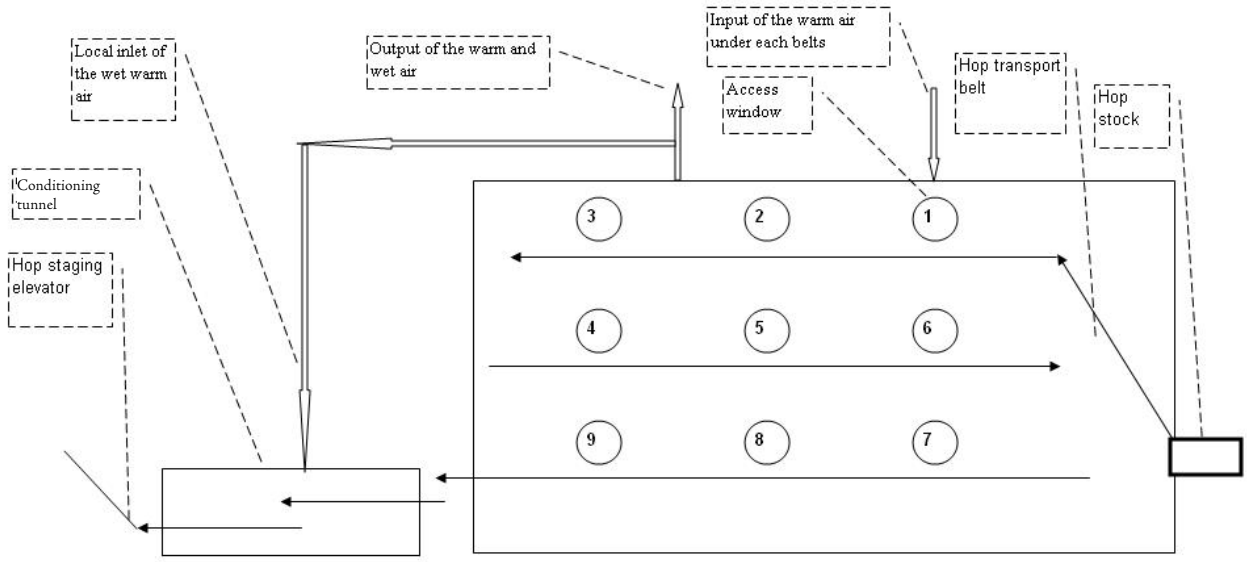

Figure 1. Technological diagram of the PSCH 325

from different distances and different heights which were transferred onto weighed trays. After weighing, the samples were dried to the constant weight in a laboratory kiln. The drying was carried out according to ČSN 01 1300 (1979), ČSN 12 6000 (1977), and ČSN 12 6001 (1977). Further, the water contents of the respective samples were calculated and averaged for each access window. For the conditioning output, the results of the Hop Research Institute Žatec were used.

Sampling for the laboratory determination of the dried hop qualitative parameters

Depending on the water contents of the hop samples taken for the follow-up of the daily dependences

Table 1. Laboratory-determined average values of α and β bitter acids, water content, and *HSI* (hop storage index) – belt hop kiln PSCH-325

Date	*p*/*pk*	α_r (%) (α bitter acids)	β_r (%) (β bitter acids)	W_r(%) (water content)	HSI_r (hop storage index)	CO
20. 8.	1	3.79	4.75	12.52	0.27	7
21. 8.	1	3.96	5.01	13.18	0.26	7
22. 8.	1	3.62	4.58	12.17	0.27	7
23. 8.	1	4.10	5.04	9.02	0.26	8
24. 8.	1	3.90	4.43	14.38	0.28	7
25. 8.	1	4.27	5.27	8.40	0.27	8
26. 8.	1	4.30	5.51	8.35	0.29	8
27. 8.	1	4.25	5.36	8.65	0.26	8
20. 8.	2	4.49	5.48	8.85	0.28	
21. 8.	2	3.91	5.12	9.82	0.26	
22. 8.	2	3.83	4.53	9.23	0.27	
23. 8.	2	3.38	4.36	9.23	0.27	
24. 8.	2	4.21	4.77	10.23	0.27	
25. 8.	2	4.00	5.14	9.23	0.27	
26. 8.	2	4.21	5.24	9.10	0.30	
27. 8.	2	3.73	4.88	9.75	0.26	

CO – number of the access belt hop kiln window

of the hop moisture content on the drying time, the access window were selected in which the water content was nearest to the 10% required. These access windows were 7 and 8 with the PSCH-325 used. With respect to the objective results of the mathematical-statistical analysis (KÁBA 1980), 6 random samples of dried hop were taken daily out of the windows given above for the laboratory treatment and for the determination of the qualitative parameters. For the same reason, 6 samples were taken also at the output of the conditioning tunnel. The samples from the access windows were allowed to stabilise under the common conditions in the building. The samples taken at the conditioning tunnel output were hermetically sealed in sachets. All 12 daily samples were continuously delivered to the Hop Research Institute Žatec.

RESULTS AND DISCUSSION

The hop harvest (Saaz semi-early red bine hop) as well as the measurements were realised in the period of 20. 8.–27. 8. 2004. The air temperature in the hop kiln PSCH-325 was 60°C, the average water content of the input hop was 77.63–81.50%.

Results of the hop analysis

In Table 1, a comprehensive overview is given of the average values of the qualitative parameters obtained on individual days of the harvest. Table 2 presents a comprehensive overview of the average values of the qualitative parameters averaged before and after conditioning and termed α_{rpp} (%), HSI_{rpp}, W_{rpp} (%), β_{rpp} (%). These values were used in the mathematical-statistical analysis of the results, based on the testing of the significance of the differences between the averaged qualitative parameters of the hop samples taken from the kiln before and after conditioning. The results of the analysis of the hop samples taken from the belt kiln, as determined by the Hop Research Institute Žatec, Ltd., are defined by the:

– time of the sampling before or after conditioning (p or pk, respectively)
– average of the sample water content, W_r (%)
– average of α bitter acids content (%) as determined by the spectrophotometric method according ASBC
– average of β bitter acids content (%)
– number of the access windows from which the samples were taken before conditioning, CO.

Significance of the differences between the average qualitative parameters during the harvest period

With regard to the mostly considerable variability in physical characteristics and qualitative parameters of the natural agricultural products, average values are used for their disciption and evaluation as determined in long-term, systematically repeated experiments and measurement.

Table 3 presents the selective averages of the qualitative parameters α (%) β (%), *HSI*, and water content *W* (%) of the respective samples taken from the belt kiln before and after conditioning of the dry hop, as well as the differences marked according to their relevance (V yes, N not) at 5% level of significance. Further, the selective averages of the parameters given above and the results of the tests of significance of the respective differences are given

Table 2. Average values of α and β bitter acids, the water content, and *HSI* (hop storage index) all the samples taken from the belt hop kiln PSCH-325 before and after conditioning

Date	α_{rpp} (α bitter acids)	β_{rpp} (β bitter acids)	W_{rpp} (water content)	HSI_{rpp} (hop storage index)
20. 8.	4.14	5.12	10.69	0.28
21. 8.	3.94	5.07	11.50	0.26
22. 8.	3.73	4.56	10.70	0.27
23. 8.	3.74	4.70	9.13	0.27
24. 8.	4.06	4.60	12.31	0.28
25. 8.	4.14	5.21	8.82	0.27
26. 8.	4.26	5.38	8.73	0.30
27. 8.	3.99	5.12	9.20	0.26

Table 3. Summary of selective α (%), β (%), *HSI*, *W* (%) averages and their differences in the terms of 20. 8.–23. 8. 2004 (1o) and of 24. 8.–27. 8. 2004 (2o) before (PRK) and after (POK) conditioning of dried hop, the corresponding probabilities (pairing *t*-tests (PA), with different or similar variances (PR,SR)) and differences selective averages relevancy (V = yes, N = no) at 5% significance level

	PRK				POK				PRK/POK				PRK/POK				PRK + POK			
			differ.				differ.				differ.				differ.				differ.	
	1o	2o	PA PR/SR	α rel.	1o	2o	PA PR/SR	α rel.	1o	1o	PA PR/SR	α rel.	2o	2o	PA PR/SR	α rel.	1o	2o	PA PR/SR	α rel.
			0.315				0.132				0.037				0.146				0.054	
			PA	0.011			PA	0.173			PA	0.913			PA	0.474			PA	0.751
α (%)	3.867	4.182		V	3.903	4.036		N	3.867	3.903		N	4.182	4.036		N	4.024	3.970		N
			SR	0.011			PR	0.286			PR	0.895			PR	0.373			PR	0.725
				V				N				N				N				N
			0.293				0.138				0.022				0.133				0.054	
			PA	0.038			PA	0.328			PA	0.930			PA	0.494			PA	0.746
β (%)	4.847	5.140		V	4.869	5.007		N	4.847	4.869		N	5.140	5.007		N	4.994	4.940		N
			PR	0.053			PR	0.324			SR	0.926			SR	0.630			SR	0.781
				V				N								N				N
			0.012				0.003				0.007				0.002				0.003	
			PA	0.047			PA	0.644			PA	0.182			PA	1.000			PA	0.351
HSI	0.263	0.275		V	0.270	0.273		N	0.263	0.270		N	0.275	0.273		N	0.270	0.273		N
			PR	0.095			PR	0.667			PR	0.360			PR	1.000			PR	0.678
				N				N				N				N				N
			1.775				0.296				2.438				0.367				1.404	
			PA	0.046			PA	0.183			PA	0.072			PA	0.790			PA	0.129
W (%)	11.721	9.946		V	9.283	9.579		N	11.721	9.283		N	9.946	9.579		N	10.834	9.430		N
			PR	0.038			PR	0.143			PR	0.075			PR	0.822			PR	0.156
				V				N				N				N				N

as obtained in the experiments carried out in the first and second harvest periods. For the evaluation of the differences, the pairing *t*-test was used both for dependent sets and those with similar (SR) or different (RR) variance. As obvious in the table, the differences between the average values of the qualitative parameters and the water contents of the samples of hop, which was harvested in the term of 20. 8.–23. 8. 2004, taken before and after conditioning are not conclusive at the 5% level of significance. The same applies to the harvesting term of 24. 8.–27. 8. 2004. Presented in the table are also the results of the tests of significance of the differences between the selective averages of α (%), β (%), *HSI*, and *W* (%) concerning the whole harvest term of 20. 8.–27. 8. 2004, which were affected by the inconclusive differences found in the first and second terms of harvest. Also in this case are the differences between the selective averages of the parameters followed in the hop samples taken before and after conditioning inconclusive at the 5% level of significance.

Table 3 further presents the selective averages of the parameters monitored and the results of the significance tests of the differences as found between the first and the second harvest terms. Obviously, the differences between the qualitative parameters and the water contents in the samples coming from the first and second terms of harvest and taken before conditioning are mostly relevant at 5% level of significance (according to paired *t*-tests), while the differences between the same parameters and related to the samples taken after conditioning were irrelevant at 5% level of significance.

All the insignificant differences found between the qualitative parameters of the hop dried in the belt kiln and subsequently conditioned only characterise the drying technology used and are in no relation to the possible changes caused by further manipulation and storage. The results are valuable especially in terms of comparison between the drying process in the belt kiln and those in other kiln types as concerns the efficiency, drying quality, and energy requirements.

DISCUSSION

The results of the measurements carried out under the given conditions together with the evaluation of freshly dried hop reveal that the abolishment of the conditioning part of the belt kiln would not result in the deterioration of the hop qualitative parameters. At the same time, the reduction of energy and repair costs could be logically presumed. Moreover, the drying process would speed up, thus resulting in further cost reduction.

CONCLUSION

For the reasons given in the preceding text, it appears useful to abolish the conditioning part of the hop drying process and, at the same time, to terminate the hop drying at the moisture content falling below 10°C. With the present-day hop kilns, this aim can be achieved in two ways, i.e. by the acceleration of the belts, or by the elimination of the last belt and slowing down of the preceding ones.

List of symbols

HSI – hop storage index
rpp – averaged values before and after climatization
r – average of the value
p – the sample before climatization withdrawaled
pk – the sample after climatization withdrawaled
PRK – values were measured in the first part of the harvesting week
POK – values were measured in the second part of the harvesting week
PA – pairing *t*-test
SR – *t*-test with sets with similar variance,
RR – *t*-test with sets with different variance
PSCH – belt hop kiln
CO – number of the access belt hop kiln window
ASBC Methods of Analysis – set of the physico-chemical, analytical, microbiology, sensorial and statistic methods for classification of the brewing materials

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Abstrakt

Mejzr J., Hanousek B. (2007): **Sušení chmele.** Res. Agr. Eng., **53**: 155–160.

V ČR se používá k technologii sušení převážně pásových sušáren. Protože se v zahraničí využívají ve větší míře i jiné typy sušáren, jako například komorové sušárny, nabízí se otázka porovnání efektivnosti a kvality technologického procesu sušení jednotlivých typů sušáren. Cílem práce bylo zjistit, jaké jsou parametry sušení chmele v pásové sušárně a jejich optimalizace.

Klíčová slova: chmel; sušení; pásová sušárna chmele; kvalitativní parametry

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