NITRATES IN HOP CONES AND BEER

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INTRODUCTION

During the last decade a lot of Slovene hop growers attention was focused on ecologically balanced production of hop and on introduction of the system of hazard analysis and critical control points (HACCP). One of the most important components in defining critical control points for beer is also the control of plant nutrition. It reflects through the influence of different nutrition levels in the quality of beer as the final product. The contents of nitrates in hop cones can vary a lot. Different quantities of added nitrogen fertilizers can result in higher or lower content of nitrates in the beer.

The acumulation of nitrates in hop cones is the result of nitrogen overmuches. The content of nitrates can be influenced by nitrogen fertilization. It means an adequate quantity and form of nitrogen fertilizer and also an optimal time and the way of application (Majer, 1994). The overmuches of nitrates in hop cones also influence on the quantity of nitrates in beer which mustn't be higher than in drinking-water (Gmelch s sod., 1990; Maier, 1989; Postel, 1976).

METHODS

In our research the influence of different quantities of nitrogen (0, 50, 100, 150, 200, 250, 300, 350, 400, 450, 500 and 600 kg of nitrogen/ha) on the quantity of nitrates in cones and in beer was investigated. For the experiment the cones of Slovenian hop cultivars Savinjski golding and Aurora were used. The nitrogen was added in three equal portions in the last decade of may, in the middle of June and in the first decade of July respectively.

In the state of technological maturity the water content with gravimetric method, the content of alpha acids with conductometric method (Analytica-EBC, 1987) and the content of nitrates with HPLC method (Donhauser et al, 1989) were defined.

For beer making the wort from industrial production with 12 % of extract was used. In the wort the analysis of nitrates content with liquid chromatography (HPLC) with UV-VIS detector by 205 nm was made (Kač et al, 1996). Hopping lasted 90 minutes. The quantity of hop which was added to wort was calculated on addition 100 mg of alpha acids per one litre and distributed into three equal portions added successively:

$$\text{quantity of hop (kg/hl)} = \frac{\text{hopping wort (hl)} \times 100\ \text{mg/l alpha acids}}{\text{\% alpha acids in air dry hop}}$$

In the hopping wort the analysis of nitrates content was made by the same method as in the wort.

A real input of nitrates in hopping wort was calculated by standard formula (Hops and Hops Product, 1997):

$$\text{real input (mg/l)} = \text{total content of nitrates in hopping wort} - \text{content of nitrates in diluted wort}$$

The fermentation of hopping wort lasted 7 days under the procedure of classical bottom fermentation. After that the beer aginged still for 14 days. In the beer the analysis of nitrate content was made and real (same method as in the hopping wort) and theoretical input of nitrates with hop cones were calculated by standard formula (Hops and Hops Product, 1997):

$$\text{theoretical input (mg/l)} = \text{quantity of hop (kg/hl)} \times \text{content of nitrates in hop cones (\%)} \times 100$$

RESULTS

Table 1: Nitrates content in hop cones, wort, hopping wort and beer in dependence from the quantity of nitrogen (cultivar Savinjski golding)Quantity of nitrogen

Quantity of nitrogen [kg/ha]	Nitrates in cones [mg/100 g]	Nitrates in wort [mg/l]	Nitrates in hopping wort [mg/l]	Real input in hopping wort [mg/l]	Nitrates in beer [mg/l]	Real input in beer [mg/l]	Theoretical input in beer [mg/l]
0	76	3,0	22,1	19,1	20,6	17,6	1,8
50	883	4,9	30,0	25,2	33,4	28,6	19,0
100	1153	3,3	38,9	35,6	26,0	22,7	26,2
150	1185	6,7	43,0	36,3	37,9	31,2	31,2
200	1302	4,3	45,4	41,1	38,8	34,5	31,4
250	1351	6,3	44,6	38,3	37,7	32,8	32,6
300	1321	4,9	42,4	37,5	47,5	42,6	34,7
350	1374	4,3	46,2	41,9	44,4	40,1	33,8
400	1419	3,3	53,6	50,3	38,7	35,4	35,4
450	1414	6,3	45,0	38,7	43,0	36,7	35,4
500	1467	3,0	46,9	43,9	47,9	44,9	39,6
600	1428	6,7	48,5	41,8	47,5	40,8	40,1
average*	1300	4,9	44,0	39,1	40,3	35,5	32,7

*average on fertilized trials

Table 2: Nitrates content in hop cones, wort, hopping wort and beer in dependence from the quantity of nitrogen (cultivar Aurora)

Quantity of nitrogen [kg/ha]	Nitrates in cones [mg/100 g]	Nitrates in wort [mg/l]	Nitrates in hopping wort [mg/l]	Real input in hopping wort [mg/l]	Nitrates in beer [mg/l]	Real input in beer [mg/l]	Theoretical input in beer [mg/l]
0	491	4,5	10,4	5,9	11,2	6,7	4,2
50	802	4,8	14,2	9,4	14,6	9,8	6,8
100	1171	5,1	17,7	12,6	19,8	14,7	10,3
150	1219	4,6	19,8	15,2	18,1	13,5	11,7
200	1552	4,8	22,7	17,9	19,7	14,9	14,2
250	1376	3,9	16,5	12,6	7,6	3,7	12,3
300	1543	3,9	17,9	14,0	12,9	9,0	15,9
350	1544	1,5	16,5	15,0	12,1	10,6	13,8
400	1892	1,8	17,2	15,4	6,0	4,2	17,6
450	1699	1,4	16,4	15,0	8,5	7,1	15,6
500	1572	< 1,0	17,6	16,6	19,1	18,1	14,8
600	1728	3,9	17,8	13,9	16,7	12,8	15,8
average*	1460	3,3	17,7	14,3	14,1	10,8	13,5

*average on fertilized trials

CONCLUSIONS

We found out that the content of nitrates in cones from nonfertilized trials was lower than in cones from fertilized trials. The average content of nitrates in the cones from nonfertilized trials of Savinjski golding was only 76 mg /100 g of dry cones but the average in the cones from fertilized trials was 1300 mg/100 g of dry cones. The cones of nonfertilized Aurora had in average 491 mg/100 g of dry cones and the cones from fertilized Aurora had about 1460 mg/100 g of dry cones. The content of nitrates in cones was mainly increased with higher portion of nitrogen. The differences are statistically significant.

The influence of nitrogen fertilization on nitrate content in beer is more difficult to evaluate because the content of nitrates in beer is the total sum of nitrates contributed by wort (water, malt) and hop. The real input of nitrates in beer was lower by hopping with cones from nonfertilized trials in comparation to fertilized trials (by Savinjski golding in average for 50 % and by Aurora for 38 %). In most trials higher portion of nitrogen increased nitrates content in beer. Different portions of nitrogen and different contents of nitrates in cones had more significant influence on the content of nitrates in beer by cultivar Aurora. By Savinjski golding the differences between trials were less significant. Considerable differences were found in comparison between real and theoretical input of nitrates into beer.

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