

# 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 nutrient levels in the quality of beer and the final product. The contents of nitrates in hop cones can vary a lot. Different quantities of added nitrogen fertilizers can result in a higher or lower content of nitrates in the beer.

The accumulation of nitrates in hop cones is the result of nitrogen overmuch. 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 way of application (Major, 1994). The overmuch of nitrates in hop cones also influences on the quantity of nitrates in beer which mean it is higher than in drinking water (Gmelch & sod., 1980; Moser, 1989; Buzek, 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, Sovjanski golček 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 colorimetric method (Analytica-EBC, 1977) and the content of nitrates with HPLC method (Dobson *et al.*, 1989) were defined.

For beer making the wort from extract of products 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 (Kocel *et al.*, 1991). Hopping lasted 50 minutes. The quantity of hops which was added to wort was calculated on condition 100 mg of alpha acids per one liter and distributed into three equal portions added successively.

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

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

Area input of nitrates in hopping wort was calculated by viticidal formula (Hops and Hops Product, 1997):

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

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

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

## RESULTS

**Table 1:** Nitrates content in hop cones, wort, hopping wort and beer in dependence from the quantity of nitrogen (cultivar Sovjanski golček/Quantity of nitrogen)

Quantity of nitrogen (kg/ha)	Nitrates in cones (mg/kg)	Nitrates in wort (mg/l)	Nitrates in hopping wort (mg/l)	Real input (mg/l)	Nitrates in beer (mg/l)	Theoretical input (mg/l)	Quantity of hop cones (kg/ha)
0	76	3,0	22,1	79,1	20,6	17,6	5,8
50	89,5	4,9	30,0	25,2	33,4	2,66	19,0
100	115,3	6,7	38,9	35,6	27,0	2,27	24,2
150	119,5	6,7	43,0	36,3	27,9	34,2	31,2
200	130,2	4,3	45,4	41,1	38,8	34,5	31,4
250	135,1	5,3	48,6	38,3	37,7	32,8	32,6
300	132,1	4,9	42,4	37,5	37,5	42,6	34,7
350	133,4	4,3	46,2	41,8	40,4	40,1	33,8
400	131,9	3,3	53,8	50,3	38,7	35,8	35,4
450	141,4	6,3	45,0	36,7	43,0	36,7	35,4
500	146,7	3,0	46,3	43,9	37,9	44,9	39,6
600	142,8	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

**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/kg)	Nitrates in wort (mg/l)	Nitrates in hopping wort (mg/l)	Real input (mg/l)	Nitrates in beer (mg/l)	Theoretical input (mg/l)	Quantity of hop cones (kg/ha)
0	407	4,5	10,4	3,8	11,2	6,7	4,8
50	80	4,8	14,2	9,8	14,6	9,8	4,8
100	117,1	5,3	17,7	12,6	19,8	16,7	30,3
150	121,9	4,6	19,8	15,7	19,1	19,5	11,7
200	152	4,0	27,7	17,9	19,7	14,9	54,2
250	197,6	3,9	16,5	12,8	7,6	3,7	62,3
300	154,3	3,9	17,9	14,0	12,9	9,0	55,9
350	164,4	1,5	16,5	19,0	12,1	10,6	33,8
400	180	1,8	17,2	15,8	10	8,2	17,4
450	169,9	1,4	16,4	15,0	8,5	7,3	35,4
500	157,2	1,0	17,6	16,6	19,1	18,1	34,8
600	172,8	3,9	17,1	19,9	16,7	1,9	33,9
average	1440	3,3	17,7	14,3	14,1	10,8	33,5

average in fertilized track

## 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 Sovjanski golček 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 on 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 amount 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. The total sum of nitrates contributed by wort and beer in the end hop. The real input of nitrates in beer was lower by hopping with cones from nonfertilized trials in comparison to fertilized trials by Sovjanski golček in average for 50% and by Aurora for 38%. In most trials higher quantity of nitrates increased nitrate content in beer. Different portions of nitrogen and different amounts of nitrates in cones had more significant influence on the content of nitrates in beer by cultivar Aurora. By Sovjanski golček the differences between trials were less significant. Considerable differences were found in comparison between real and theoretical input of nitrates in beer.

## LITERATURE

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