Effect of boron fertilisation on the flavour of carrots – Applicability of organoleptic analyses to carrots

Némethy-Uzoni, H.[1] and Kókai, Z.[2]

[1]*Szent István University, Faculty of Horticultural Sciences, Department of Vegetable and Mushroom Growing H-1118 Budapest, Ménesi út 44., E-mail: zold@omega.kee.hu*
[2]*Szent István University, Faculty of Food Sciences, Sensory Evaluation Laboratory*

Summary: Foliar boron fertilisation has had positive influence only on carotene content. Results were evaluated with chemical analyses and sensory tests. It has been observed that sensory tests are able to detect bitter flavour and also to measure its interaction with sweet flavour. Sensory tests for evaluation are generally used in the EU, also in the case of fruits and vegetables. With the aid of students and staff having received training and acquired practice, our University has the possibility to complete chemical analyses in such a way that satisfies modern demands, as well as facilitating the sale of the products on foreign markets.

Key words: boron fertilisation, sugar content, sensory evaluation, carotene, carrot

Introduction

Over the last 10–15 years an increasing number of dietary and medical tests have demonstrated the beneficial effects of fruit and vegetable consumption. As a result, carrot consumption has also gained in importance.

Plant fibres and the so-called secondary plant materials (volatile oils etc) play an important role in preventing the occurrence of cancer. They are proven to inhibit the processes that produce malignant tumours. The dietary fibre content of carrot is 4.02 g/100 g fresh mass which falls within the range of the values (4–5.9 g/100 g) accustomed in the case of the vegetables taken as reference (parsley root, haricot beans, celeriac) *(Witkowska* et al., 1996).

The importance of carrot is based on its carotene content, but its flavour and aroma components are also of significance. Beta-carotene as the provitamin of vitamin A is indispensable for human organism. According to the different surveys, nutrition is deficient in vitamin A all over the world (FAO/WHO, 1998; *West* et al., 1993). Several of its volatile oils have already been scientifically proven to possess bactericid effect *(Takácsné,* 1999).

In order to raise carotene content and to improve flavour we arranged a fertilisation experiment with foliar application of boron. The beneficial effect of magnesium had already been reported in the literature (Kiss, 1990), as well as the importance and advantageous effect of boron in nitrate metabolism *(Terbe,* 1999, *Loch* et al., 1992).

The effect of foliar fertilisation was evaluated not only by means of laboratory tests, but also with organoleptic methods in search of the effect providing the best flavour. In fact the higher values of laboratory sugar content analyses do not always mean good flavour. Bitter substances, referred to as 'off-flavours' in the literature, may cover or modify the sweet flavour.

We had no possibility for volatile oil analyses in our experiments, but carried out several kinds of sensory analysis of carrot samples with the help of the Sensory Evaluation Laboratory of the Faculty of Food Sciences.

In this way, besides comparing the results of the two analyses, we had the possibility to evaluate the applicability of organoleptic methods.

Material and method

The experiment was carried out on brown forest soil with clay illuvation. Foliar fertilisation was applied 8 and 5 weeks before harvest in the case of Flakker-type varieties, and 7 and 5 weeks in the case of Nanty-type ones.

We applied Savabor in 0.5% concentration and Damisol in 1% concentration.

Carotene contents were determined with photometry from grated raw samples and sugar amounts were determined with the Luff-Schoorl method from grated raw samples.

Sensory test methods applied

Pair preference method

The Nanti-type varieties were tested by the method of pair preference analysis because here only sweet flavour and crispness were to be considered.

In the evaluation, untreated samples of Bolero and Puma varieties, as well as their Savabor or Damisol treated samples were tested. Tests were carried out in two series, first the untreated were compared to the Damisol treated, then in the second series the untreated and the Savabor treated were compared.

For the analysis, sample pairs were distributed in an arrangement so that every sample would form pairs with every sample. On the basis of the question 'Which one do you prefer?' one from each pair had to be indicated.

After reviewing the evaluation sheets the results were summarised in a matrix.

The samples listed in the rows of the table were preferred to those in the columns. Therefore, when sample A and sample B formed the same pair, A was preferred in 7 cases, while B in 3 cases.

		Less preferred				Total
		A	B	C	D	
More preffered	A	–	7	8	5	20
	B	3	–	5	5	13
	C	2	5	–	5	12
	D	5	5	5	–	15
	Total	10	17	18	15	

Samples: **A** = *Puma 0;* **B** = *Bolero 0;* **C** = *Puma Dam;* **D** = *Bolero Dam*

Calculation of rank number totals: In the present case, the more preferred sample received rank number 1 and the less preferred sample rank number 2. To calculate the rank number total of a sample, the double of the total in the corresponding column is added to the total in the row. Thus, rank number totals of the samples are: A: 40, B: 47, C: 48, D: 45.

Evaluation results

On the basis of rank number totals, the number of evaluators and the number of products the F-value of the Friedmann's test was calculated. This was then compared with the critical F-values recovered from tables. A rank order can be considered significant on the given level if the calculated F-value surpasses the F-value belonging to the significance level. Within a rank order always the sample with the lowest rank number total is the most preferred.

Profile analysis method

In profile analyses a plurality of characteristics were studied contemporarily. The evaluators rated the given characteristic according to a scale on the evaluation sheet.

First a preference order was established with visual testing, with the rank headed by the most appealing and attractive sample. Then, a detailed evaluation followed, involving orange colour, crispness, odour intensity, sweet flavour, bitter flavour intensity and overall impression.

Now, the result of the evaluation did not consist of a sequence of rank numbers, but very much differing scores according to scales (mm values read from the scale).

In this case, the Friedmann's test used for evaluating rankings based on rank numbers cannot be applied, instead the single factor analysis of variance is recommended.

Results and discussion

Response of Nanti-type varieties to boron fertilisation

Sugar content *(Figure 1)*: The total sugar content of the untreated Puma was higher than that of Bolero, and in this variety none of the treatments increased total sugar content. Damisol treatment raised total sugar content in Bolero, while slightly reducing sugar amount in Puma.

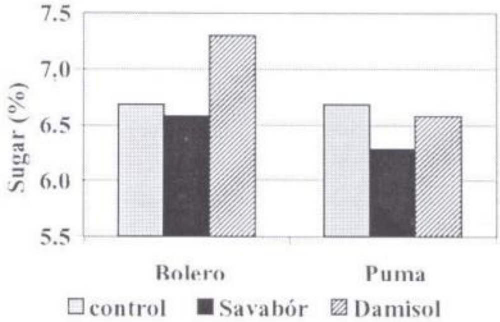

Figure 1 Changes in total sugar content in response to boron fertilisation

Carotene content *(Figure 2)*: Out of the two varieties the values for Puma show more fluctuation. Both treatments increased carotene content in Bolero, Savabor in a lesser degree, Damisol treatment in a higher degree.

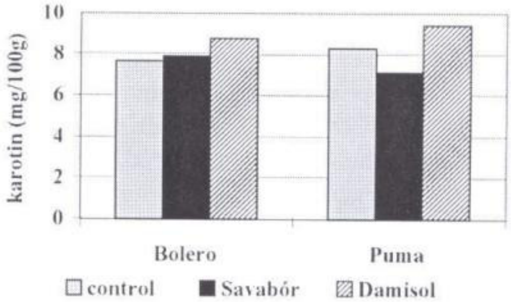

Figure 2 Changes in carotene content in response to boron fertilisation

Response of Flakker-type varieties to foliar fertilisation with boron

Sugar content *(Figure 3)*: Total sugar did not increase in either of the years as a result of foliar fertilisation with boron.

Carotene content *(Figure 4)*: Response tendencies of the two varieties were identical; the degree was higher in the case of Danvers 126 where the carotene content of untreated carrots was relatively low. In the second year, after treatment neither of the varieties reached the untreated carotene content of Danvers 126, while in the case of Flakker Damisol produced a 2% increase in carotene content.

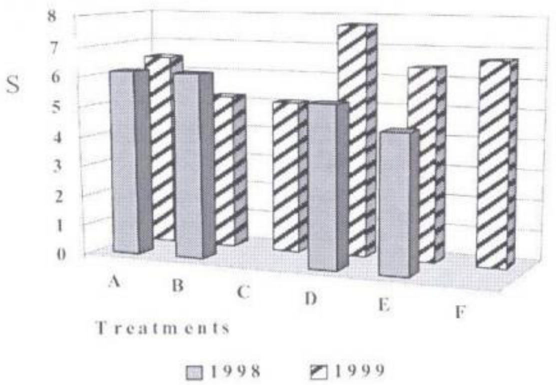

Figure 3 Influence of boron fertilisation on total sugar contents of Flakker-type varieties
A: Dalvers control, B: Dalvers Savabór, C: Dalvers Damisol, D: Flakker control, E: Flakker Savabór, F: Flakker Damisol, S: Sugar contents (%)

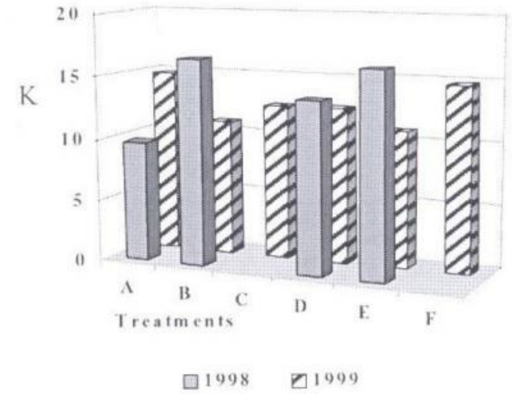

Figure 4 Influence of boron fertilisation on carotene contents of Flakker-type varieties
A: Dalvers control, B: Dalvers Savabór, C: Dalvers Damisol, D: Flakker control, E: Flakker Savabór, F: Flakker Damisol, K: Carotene contents (%)

Sensory test results

The Nanti-type varieties were tested by the method of pair preference analysis because here only sweet flavour and crispness were to be considered.

In the first series, according to the rank order both the sweetest and the crispest was the untreated Puma. On 95% probability level, none of the samples differed significantly from the others.

In the second series, according to the rank order the sweetest was the Savabor treated Puma and the least sweet the Savabor treated Bolero. The crispest was the treated Bolero and the least crisp was the untreated Bolero in the tests by the evaluators. Statistically, these samples could not be considered different, either.

The Flakker-type varieties were tested with the profile analysis method, as more characteristics had to be considered and in particular the bitter flavour covering the sweet flavour was to be analysed.

Untreated and Damisol or Savabor treated varieties of Danvers 126 and Flakker were tested with this method.

First, a visual evaluation was made, and in accordance, ranking was made based on shape, colour and uniformity. The rank was headed by the most attractive and appealing sample. Then, a detailed evaluation followed, involving orange colour, crispness, odour intensity, sweet flavour, bitter flavour intensity and overall impression.

The results calculated as percentages are shown in *Figure 5*.

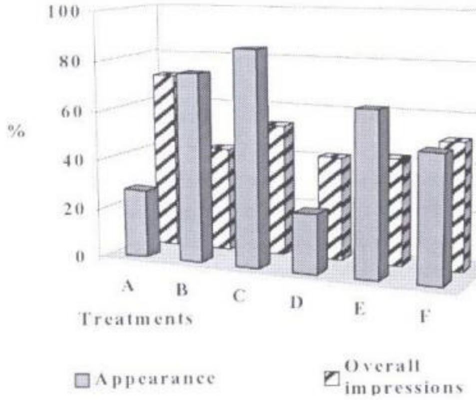

Figure 5 Evaluation of Flakker-type varieties according to appearance and overall impression
A: Dalvers control, B: Dalvers Savabór, C: Dalvers Damisol, D: Flakker control, E: Flakker Savabór, F: Flakker Damisol

Based on morphological evaluation, the Damisol treated Danvers 126 was the most appealing and the untreated Flakker gave the poorest result. According to the overall impression after tasting, the untreated Danvers 126 became the most preferred, with its sweet flavour and slight bitterness. In testing the effect of boron fertilisers we managed to see that sensory analysis was able to detect bitter flavour and to test its interaction with sweet flavour as well.

In the pair preference tests of sensory evaluations we obtained results which did not perfectly coincide with chemical measurements.

Cumulative Profile Analysis of the Flakker type shows well that it was the joint influence of sweet flavour and the

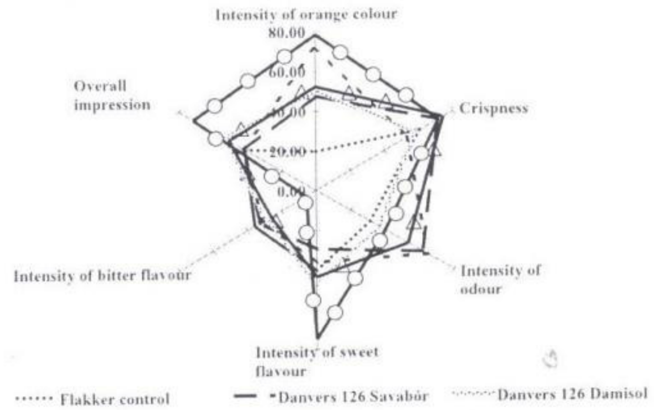

Figure 6 Profile analysis results

absence of bitterness that put untreated Danvers 126 in first place. This finding confirmed very well the results of laboratory tests by *Takácsné* (1999), where in the volatile oil contents of carrot varieties the caryophyllen content, which is responsible for bitter flavour, was much lower in Danvers 126 than in Flakker.

Further applicability of sensory evaluation methods are worth to be studied also with the other vegetables, especially the ones for fresh consumption.

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