

SENSORY QUALITY OF CARROTS FROM ORGANIC AND CONVENTIONAL CULTIVATION

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Summary

The aim of the study was to determine the effect of the cultivation method (organic and conventional) on the sensory quality of carrot roots – fresh, stored, and cooked. The study was conducted in the sensory evaluation laboratory of the Institute of Horticulture in Skierniewice in 2009-2011. The carrot roots came from a certified experimental field with a stable ecosystem, adapted for conducting experiments on the organic growing of vegetables. At the same time, in the same soil and climatic conditions, carrots were grown in the conventional system. The experimental material consisted of two varieties of carrot – Perfekcja and Regulska. In a two-year cycle, sensory analyses were performed of fresh carrot roots, and of roots that had been stored and heat treated. The evaluations were conducted by a 10-person panel of specialists using the method of quantitative descriptive analysis (QDA). The results of qualitative sensory evaluations and the profilograms prepared on that basis for fresh and stored carrot roots indicated differences in the sensory characteristics between the tested varieties grown in organic and conventional systems. The greatest impact on the overall quality was exerted by the attributes: the carrot-taste, sweet taste, juiciness and hardness of the flesh. Organically grown carrots of the variety Regulska were characterized by the highest intensity of sweet taste and the carrot-taste, and by the best hardness, crunchiness, crispness and juiciness of the flesh. Fresh roots of this variety received the highest overall score. There were also some differences in the sensory characteristics of carrot roots after several months of storage, and then after cooking them, depending on the variety and cultivation method. In both years of the study, following the storage period, the cooked carrot roots of the variety Perfekcja from organic cultivation received the highest scores for overall quality. After storing and subjecting carrot roots to heat treatment, there was a significant decrease in the intensity of most of the quality descriptors, such as taste, smell and texture, when compared with the fresh roots under evaluation.

key words: carrot, organic cultivation, sensory quality, descriptive method

INTRODUCTION

Among the important factors influencing the overall quality of a food product, in addition to its nutritional value, are its sensory characteristics. Sensory evaluation of food quality is supplementary to the physical and chemical methods. Instrument-based methods determine the properties of the product itself, whereas sensory methods provide information about how these properties are perceived by the human senses and what impression they evoke during consumption (Surmacka-Szcześniak 1993, Gawęcka & Jędryka 2001, Gawęcki & Barylko-Pikielna 2007, Barylko-Pikielna & Matuszewska 2009).

QDA (quantitative descriptive analysis) is a descriptive method representing one of the most advanced and complex sensory methods. The main objective of this method is to find the minimum number of descriptors that can provide the maximum amount of information about the sensory properties of a product. In sensory profiling, the conventionally accepted assumption is that tastiness (or texture) is a complex of a few or even more than a dozen partial taste-and-smell characteristics. A combination of all these characteristics, their intensity and relative proportions give a detailed sensory image of the evaluated product, in which it is possible to accurately track the changes occurring under the influence of various factors related to raw materials, technology, or storage (Stampanoni 1993, Meilgaard *et al.* 1999, Kołczak & Kupiec 2004).

Production of organic food is still very popular in the USA and Eu-

rope (Sloan 2003, Dimitri & Green 2002). According to Haglund *et al.* (1999), information on the organic origin of a food product increases its attractiveness to the consumer. Many authors have reported that food produced by organic farming is considered environmentally friendly, mainly because no chemicals are used (Goldman & Clancy 1991), as opposed to conventionally grown produce.

In recent years, the producers and consumers of carrot have been giving increasingly more consideration to product quality. The quality of carrot roots is attributed to a number of characteristics related to chemical composition, appearance and flavour. Research results of many authors indicate a close relationship between the sensory quality of vegetables and their physical properties and nutritional value (Fillion & Kilcast 2002, Gajewski 2003, Gajewski & Arasimowicz 2004, Szymczak *et al.* 2007, Zhao *et al.* 2007).

In the years 2009-2011, experiments were conducted, whose aim was to examine the effect of organic and conventional cultivation on the sensory quality of carrot roots - fresh, stored, and cooked.

MATERIALS AND METHODS

Two varieties of carrot were selected for the study – Perfekcja and Regulska (PNOS Ożarów), which were grown in a certified experimental field with a stable ecosystem, adapted for conducting research on the organic cultivation of vegetables. At the same time, in the same soil and

climatic conditions, carrots were grown in the conventional system.

In a two-year test cycle, sensory analysis was performed of fresh carrots and also those that had been stored and subjected to heat treatment. The storage period in the 2009/2010 season was 6 months, and in 2010/2011 - 7 months. Carrot roots were stored at 0°C and a relative air humidity of 95-98%. The roots were stored in "1/2" wooden crates lined with polythene film to maintain high relative humidity of the air inside the packaging.

For the sensory evaluation of fresh, stored and cooked carrot roots, the method of descriptive analysis was used (Quantitative Descriptive Analysis, QDA), i.e. sensory profiling, in accordance with the procedure set out in the standard PN-ISO 11035 (Analiza sensoryczna – Identyfikacja i wybór deskryptorów do ustalenia profilu sensorycznego z użyciem metod wielowymiarowych : Sensory analysis – Identification and selection of descriptors for establishing a sensory profile by using multivariate methods). A panel of 10 experts took part in the selection of quality descriptors (characteristic smell-and-taste features). Each person participating in the selection of the descriptors received carrot samples for evaluation; the samples were packed in tightly closed and coded small plastic containers. The evaluation was carried out according to pre-defined lists of quality descriptors (or attributes): odour, colour, texture/consistency, and taste for fresh and cooked carrot roots (Tables 1 & 2). Also assessed was the overall quality of the roots,

which represented the combined contribution of all the descriptors included in the evaluation. The intensity of each descriptor was assessed on a continuous graphical scale ranging from 0 to 10 cm in length, marked with appropriate boundary terms. Each evaluation was made in two independent replications. At the start of the study, the panellists selected a list of 13 quality descriptors and an overall score for the quality of fresh carrot roots before and after storage. Sensory analyses were also performed for the roots subjected to heat-treatment, both before and after storage, using 12 quality descriptors and an overall quality score. Fresh carrots to be evaluated were peeled and cut into 1 cm lengths which were then placed, 3 at a time, in each 250 ml plastic container with lid. In order to prepare samples of cooked carrots, fresh roots were washed and then cooked for 17 minutes from the time the water began to boil. The roots were then peeled and cut, and, when cold, packed in the same manner as the fresh carrot roots.

Profiling was carried out in the sensory laboratory, which met all the requirements set out in the standard PN-ISO 8589 (Analiza sensoryczna – Ogólne wytyczne projektowania pracowni analizy sensorycznej : Sensory analysis – General guidelines for designing a laboratory for sensory analysis), at six individual evaluation stations, using a computerized program ANALSENS designed for preparing tests, recording individual scores and statistical processing of the results. The results are presented in tabular form. The collected data were sub-

jected to statistical analyses, the aim of which was to compare the mean values of the studied characteristics. A two-way analysis of variance in a completely randomized design was carried out, in which factor A was the

cultivar, while factor B the cultivation method. Multiple comparisons of mean values for combinations were performed using Tukey's test. The analyses were performed at a significance level of $\alpha=0.05$.

Table 1. Sensory quality descriptors used in the evaluation of fresh carrot roots and their definitions

Quality descriptor	Definition	Boundary terms
The carrot-smell	The smell characteristic of raw carrot	Imperceptible - very intense
Sweet smell	Positive impression while sniffing the sample of carrot	Imperceptible - very intense
Foreign smell	An unusual smell for carrot	Imperceptible - very intense
Colour of the outer skin	Visual assessment of skin colour intensity	Light orange - dark orange
Colour of the longitudinal section of the root	Visual assessment of the colour of the root's section	Light orange - dark orange
Crispness of the flesh	The intensity of sound heard while biting into the sample with the front teeth	No sound - very noisy
Hardness of the flesh	The force needed to crush the sample with the molar teeth	Soft - hard
Crunchiness of the flesh	Repetitive noisy sound during chewing of the sample with the molar teeth	Short, quiet sound - long, loud sound
Juiciness of the flesh	The impression of free juice flowing out when crunching up a piece of carrot	No juiciness - very juicy
The carrot-taste	The taste characteristic of raw carrot	Imperceptible - very intense
Sweet taste	Basic taste	Imperceptible - very intense
Bitter taste	Basic taste	Imperceptible - very intense
Foreign taste	An unusual taste for carrot	Imperceptible -very intense
Overall quality score	Overall impression covering all the quality descriptors	Poor quality - very good quality

Table 2. Sensory quality descriptors used in the evaluation of cooked carrot roots and their definitions

Quality descriptor	Definition	Boundary terms
The cooked carrot smell	The smell characteristic of carrot	Imperceptible - very intense
Sweet smell	Positive impression while sniffing the sample of carrot	Imperceptible - very intense
Foreign smell	An unusual smell for carrot	Imperceptible - very intense
Colour of the longitudinal section of the root	Visual assessment of the colour of the root's longitudinal section	Light orange - dark orange
Uniformity of skin colour	Visual assessment of skin colour intensity	Not very uniform - very uniform
Stringiness	Negative description of long pieces of fibers arranged in the same direction	Not very fibrous - fibrous
Consistency of the flesh	A group of features detected by the stimulation of mechanical and tactile receptors	Not very compact - very compact
The cooked carrot taste	The taste characteristic of carrot	Imperceptible - very intense
Sweet taste	Basic taste	Imperceptible - very intense
Bitter taste	Basic taste	Imperceptible - very intense
Foreign taste	An unusual taste for carrot	Imperceptible - very intense
Overall quality score	Overall impression covering all the quality descriptors	Poor quality - very good quality

RESULTS AND DISCUSSION

The sensory quality descriptors for odour, texture and taste selected by the sensory panel in this experiment were similar to those used in the evaluations by Haglund *et al.* (1999) and Szymczak *et al.* (2007). In a study by Kreutzman *et al.* (2007), a similar list of descriptors was used, but it also included the smell of storehouse and hay, the smell and taste of the green

parts of vegetables, and a soapy taste; also, a 'burnt' smell was distinguished and included among foreign smells.

The results of the qualitative sensory evaluation for fresh and stored carrot roots indicate differences in the sensory characteristics of the tested cultivars grown in organic and conventional systems.

Based on the analysis of variance in the 2009/2010 storage season, it can be concluded that for fresh carrot

roots significant differences between the cultivars Regulska and Perfekcja occurred only in two descriptors of sensory quality. Roots of the cultivar Regulska were characterized by a significantly higher intensity of the carrot-smell and juiciness of the flesh in comparison with the roots of the cultivar Perfekcja (Table 3). The method of cultivation had a significant effect on the perception of foreign taste. In the roots of carrots grown by the conventional method there was a perceptible, slightly fermentative, biting aftertaste. The differences in the other quality attributes were not statistically significant (Table 3).

Taking into account the storage period, it can be concluded that in the 2009/2010 storage season carrot roots of the cultivar Regulska were characterized by a more intense colour of the outer skin of the root and of the longitudinal section of the root compared with roots of the cultivar Perfekcja (Table 3). There was no significant effect of the cultivation method on the sensory quality of those roots.

Before storage, the roots of the cultivar Regulska grown in the organic system exceeded the sensory quality attributes of the non-stored roots of this cultivar from the conventional cultivation in terms of the carrot-smell and taste, sweet smell and taste, crispness, hardness and juiciness of the flesh, and the overall quality score. By contrast, the roots of organically-grown cultivar Perfekcja were characterized by much higher scores for the texture descriptors, i.e. crunchiness, hardness and crispness of the flesh (Table 5). Statistically significant differences between the cultivars and

cultivation methods were found only in the carrot-smell. Completely different results had been obtained by Haglund *et al.* (1999), according to which the roots of carrots grown by the conventional method were sweeter and more crunchy than those from organic cultivation.

After 6 months of storage, the roots of the carrot variety Regulska from organic cultivation received the highest scores in terms of the carrot-smell, colour, texture, the carrot-taste and sweet taste, and the overall score (Table 5). Similar results had been obtained by Hogstad (1997) and Haglund *et al.* (1999). In their research they found that organically-grown carrots were characterized by a much more intense carrot-smell and carrot-taste, and also sweet taste, as well as a perceptible bitter taste in comparison with conventionally-grown carrots. By contrast, the roots of the variety Perfekcja grown by the conventional method were characterized by the lowest intensity of the carrot-smell and carrot-taste, sweet smell and sweet taste, and crunchiness of the flesh.

In 2010-2011, fresh carrot roots from organic cultivation scored higher with their taste-and-smell attributes than the roots from conventional cultivation. Statistically significant differences in the sensory quality profiles of fresh carrot roots before storage were found in the carrot-taste and sweet taste, hardness and juiciness of the flesh, and the overall quality score (Table 4). Studies on the sensory quality of organically-grown vegetables had been the subject of work by Rembiałkowska (2002), who had

shown that the quality of carrots, assessed in terms of colour, sweet smell and taste, hardness and consistency was higher in the product produced on an organic farm. According to this author, the factors that had a significant effect on the results included the weather conditions during harvest and the length of the storage period. Similar results had been obtained by Haglund *et al.* (1999), who observed a significant effect of the cultivar and climate-and-soil conditions in a given year on the intensity of the sensory attributes of carrot roots.

Analyzing the results of the sensory analysis of carrot roots before and after storage, it can be stated that there occurred statistically significant differences between the cultivars and cultivation methods (Table 4). There were statistically significant differences in the scores for the carrot-smell and carrot-taste, and in the overall quality score. There was a slight decrease in some of the attributes, such as the smell, taste and texture of the analyzed carrot roots after storage. There was no effect of any foreign smells or tastes on the quality of carrot roots after storage. In a study by Gajewski and Dąbrowska (2007) it had been found that the intensity of untypical smells and tastes was usually observed in the roots held in storage.

In the roots of the variety Regulska from organic cultivation there was the highest intensity of sweet taste and the carrot-taste, and also the best hardness, crunchiness, crispness and juiciness of the flesh, as well as

the highest scores for the overall quality (Table 5).

After several months of storage, Perfekcja carrot roots from organic cultivation had the highest intensity of most of the quality attributes. The roots of this variety were characterized by the highest intensity of sweet taste and the typical carrot-taste, the best texture and the highest value of the overall quality rating (Table 5).

Differences were also found in the intensity of some sensory attributes in carrot roots after several months of storage, and then after cooking them, depending on the variety and method of cultivation. In the first year of storage, the roots of the conventionally-grown carrot variety Perfekcja received the highest scores for the cooked carrot taste, uniformity in the colour of the skin of the root and in the intensity of the colour of the longitudinal section of the root. However, this variety received the lowest marks for the overall quality of the product. Statistically significant differences were only noted in the uniformity of the colour of the skin (Table 6).

In the 2010-2011 storage season, carrot roots of the variety Regulska from organic cultivation were characterized by a much greater intensity of the cooked carrot taste, cooked carrot smell and sweet taste, and received the highest score for the overall sensory quality. Statistically significant differences were only noted for the uniformity of the colour of the skin and for the stringiness of the flesh (Table 6).

Table 3. Summary of p-probability results of F-test statistics for the quality descriptors of fresh and stored carrot roots in the 2009/2010 season

Smell, colour, texture and taste descriptors	Organically grown carrots	Conventionally grown carrots	Statistical significance of differences between cultivation methods	Regulska	Perfekcja	Statistical significance of differences between cultivars
Results of sensory evaluation before storage in 2009/2010						
<u>Smell</u>						
1. carrot-smell	5.72	5.50	Ns	6.35	4.87	*
2. sweet	2.77	2.54	Ns	3.18	2.13	Ns
3. foreign	0.01	0.12	Ns	0	0.14	Ns
<u>Colour</u>						
4. outer skin	5.02	5.28	Ns	5.32	4.97	Ns
5. longitudinal section	5.25	5.32	Ns	5.29	5.29	Ns
<u>Texture</u>						
6. crispness	8.29	7.70	Ns	7.86	8.12	Ns
7. hardness	7.88	7.23	Ns	7.47	7.63	Ns
8. crunchiness	7.37	7.20	Ns	7.35	7.22	Ns
9. juiciness	4.41	3.90	Ns	4.57	3.74	*
<u>Taste</u>						
10. carrot-taste	6.03	5.16	Ns	5.90	5.28	Ns
11. sweet	3.43	2.41	Ns	3.18	2.65	Ns
12. bitter	0.45	0.78	Ns	0.40	0.82	Ns
13. foreign	0.01	0.15	*	0	0	Ns
14. Overall quality score	5.39	4.58	Ns	5.38	4.60	Ns
Results of sensory evaluation after storage in 2009/2010						
<u>Smell</u>						
1. carrot-smell	6.0	5.46	Ns	6.13	5.33	Ns
2. sweet	3.07	2.83	Ns	3.28	2.62	Ns
3. foreign	0	0	Ns	0	0	Ns
<u>Colour</u>						
4. outer skin	5.77	5.95	Ns	6.17	5.55	*
5. longitudinal section	5.93	5.94	Ns	6.30	5.56	*
<u>Texture</u>						
6. crispness	7.85	7.68	Ns	7.79	7.73	Ns
7. hardness	7.66	7.31	Ns	7.46	7.51	Ns
8. crunchiness	7.38	7.04	Ns	7.30	7.12	Ns
9. juiciness	4.67	4.41	Ns	4.60	4.48	Ns
<u>Taste</u>						
10. carrot-taste	6.13	5.88	Ns	6.30	5.71	Ns
11. sweet	3.52	3.15	Ns	3.66	3.0	Ns
12. bitter	0.77	0.77	Ns	0.82	0.72	Ns
13. foreign	0	0	Ns	0	0	Ns
14. Overall quality score	5.91	5.75	Ns	5.95	5.71	Ns

* – differences significant at $p < 0.05$, Ns – differences not statistically significant

Table 4. Summary of p-probability results of F-test statistics for the quality descriptors of fresh and stored carrot roots in the 2010/2011 season

Smell, colour, texture and taste descriptors	Organically grown carrots	Conventionally grown carrots	Statistical significance of differences between cultivation methods	Regulska	Perfekcja	Statistical significance of differences between cultivars
Results of sensory evaluation before storage in 2010/2011						
<u>Smell</u>						
1. carrot-smell	7.14	6.28	Ns	6.72	6.71	Ns
2. sweet	5.56	4.43	Ns	4.84	5.15	Ns
3. foreign	0.01	0.02	Ns	0	0.03	Ns
<u>Colour</u>						
4. outer skin	5.31	5.43	Ns	5.22	5.52	Ns
5. longitudinal section	5.55	5.21	Ns	5.18	5.58	Ns
<u>Texture</u>						
6. crispness	8.04	7.43	Ns	7.87	7.60	Ns
7. hardness	7.81	6.83	*	7.53	7.11	Ns
8. crunchiness	6.96	6.42	Ns	6.88	6.50	Ns
9. juiciness	6.35	5.39	*	6.16	5.58	Ns
<u>Taste</u>						
10. carrot-taste	7.69	6.67	*	7.24	7.12	Ns
11. sweet	6.42	4.70	*	5.91	5.22	Ns
12. bitter	0.21	0.41	Ns	0.26	0.36	Ns
13. foreign	0	0	Ns	0	0	Ns
14. Overall quality score	7.73	6.02	*	7.10	6.65	Ns
Results of sensory evaluation after storage in 2010/2011						
<u>Smell</u>						
1. carrot-smell	6.86	6.67	Ns	6.94	6.59	*
2. sweet	4.39	4.01	Ns	4.35	4.05	Ns
3. foreign	0	0	Ns	0	0	Ns
<u>Colour</u>						
4. outer skin	6.30	6.54	Ns	6.44	6.40	Ns
5. longitudinal section	6.08	6.31	Ns	6.31	6.09	Ns
<u>Texture</u>						
6. crispness	7.62	7.34	Ns	7.30	7.66	Ns
7. hardness	7.31	7.19	Ns	7.04	7.46	Ns
8. crunchiness	7.02	6.89	Ns	6.74	7.18	Ns
9. juiciness	5.15	4.46	Ns	4.60	5.02	Ns
<u>Taste</u>						
10. carrot-taste	6.91	6.22	*	6.39	6.75	Ns
11. sweet	4.66	3.69	Ns	3.91	4.44	Ns
12. bitter	0.64	0.84	Ns	0.86	0.63	Ns
13. foreign	0	0	Ns	0	0	Ns
14. Overall quality score	6.58	5.67	*	5.97	6.28	Ns

Note: see Table 4

Table 5. Sensory evaluation of fresh carrot roots based on quality descriptors (scale 0-10)

Cultivar	Cultivation method	Storage	Sensory descriptors													
			Carrot-smell	Sweet smell	Foreign smell	Outer skin colour	Longitudinal section colour	Crispness	Hardness	Crunchiness	Juiciness	Carrot-taste	Sweet taste	Bitter taste	Foreign taste	Overall score
			Years 2009/2010													
Regulska	conventional	before	6.34b	3.18a	0.05a	5.59a	5.43a	7.63a	7.43a	7.43a	4.24a	5.42a	2.51a	0.17a	0.12a	5.08a
		after	6.10a	3.34a	0.01a	6.0b	6.13ab	7.55a	7.18a	7.12a	4.35a	6.13a	3.35a	1.10a	0.0a	5.67a
	organic	before	6.37b	3.19a	0.06a	5.06a	5.15a	8.09a	7.52a	7.27a	4.91a	6.39a	3.86a	0.63a	0.03a	5.67a
		after	6.16a	3.22a	0.0a	6.35b	6.48b	8.04a	7.75a	7.47a	4.86a	6.47a	3.98a	0.54a	0.0a	6.23a
Perfekcja	conventional	before	4.67a	1.90a	0.19a	4.97a	5.22a	7.76a	7.02a	6.97a	3.56a	4.90a	2.31a	1.39a	0.18a	4.08a
		after	4.82a	2.32a	0.0a	5.91ab	5.74ab	7.80a	7.45a	6.96a	4.47a	5.62a	2.95a	0.44a	0.0a	5.83a
	organic	before	5.07ab	2.36a	0.10a	4.98a	5.36a	8.49a	8.24a	7.47a	3.91a	5.67a	2.89a	0.26a	0.0a	5.12a
		after	5.83a	2.93a	0.0a	5.19a	5.38a	7.66a	7.57a	7.28a	4.48a	5.80a	3.06a	1.0a	0.01a	5.59a
Regulska	conventional	before	6.38a	4.24a	0.0a	5.38a	5.30a	7.58a	6.92a	6.69a	5.65a	6.49a	4.88a	0.35a	0*	6.0a
		after	6.92a	4.33a	0*	6.66a	6.51a	7.11a	7.05a	6.65a	4.23a	6.03a	3.17a	1.09a	0*	5.42a
	organic	before	7.06a	5.44a	0.01a	5.06a	5.07a	8.17a	8.15a	7.08a	6.68a	7.99a	6.94b	0.18a	0*	8.20b
		after	6.96a	4.37a	0*	6.22a	6.11a	7.49a	7.02a	6.81a	4.96a	6.75a	4.65a	0.63a	0*	6.52a
Perfekcja	conventional	before	6.19a	4.62a	0.05a	5.48a	5.13a	7.29a	6.75a	6.16a	5.14a	6.95a	4.53a	0.47a	0*	6.04a
		after	6.41a	3.69a	0*	6.41a	6.11a	7.56a	7.33a	7.12a	4.69a	6.42a	4.21a	0.60a	0*	5.92a
	organic	before	7.23a	5.69a	0.02a	5.57a	6.03a	7.91a	7.47a	6.85a	6.02a	7.40a	5.91ab	0.25a	0*	7.26ab
		after	6.77a	4.41a	0*	6.39a	6.06a	7.75a	7.59a	7.24a	5.35a	7.07a	4.68a	0.66a	0*	6.64a

* dependent variable shows no variation

Values marked with the same letter in columns for a given storage season are not significantly different at $p=0.05$ according to Tukey's test

Table 6. Sensory evaluation of cooked carrot roots based on quality descriptors (scale 0-10)

Cultivar	Cultivation method	Storage	Sensory descriptors												
			Cooked carrot smell	Sweet smell	Foreign smell	Uniformity of skin colour	Colour (longitudinal section)	Stringiness of flesh	Consistency of flesh	Cooked carrot taste	Sweet taste	Bitter taste	Foreign taste	Overall score	
Years 2009/2010															
Regulska	conventional	before	7.26a	2.97a	0.01a	6.67a	7.22a	0.85a	6.99a	6.17a	3.68a	1.30a	0.0a	5.60a	
		after	6.68a	2.66a	0.06a	6.83b	6.36a	0.58a	6.06a	6.63a	4.0a	0.91a	0*	6.08a	
	organic	before	5.55a	1.92a	0.32a	5.27a	7.28a	1.16a	7.01a	6.25a	3.96a	0.47a	0.08a	5.98a	
		after	6.55a	2.99a	0.03a	6.61b	6.66a	0.66a	6.61a	6.67a	3.32a	1.14a	0*	6.07a	
Perfekcja	conventional	before	6.61a	2.21a	0.08a	5.99a	6.64a	0.59a	7.18a	6.41a	4.19a	0.72a	0.11a	5.94a	
		after	6.62a	2.87a	0.03a	6.94b	6.88a	0.50a	7.90a	7.32a	3.81a	1.40a	0*	5.85a	
	organic	before	6.34a	2.41a	0.34a	6.76a	7.84a	1.01a	6.63a	6.74a	3.86a	0.80a	0.06a	6.22a	
		after	6.51a	2.58a	0.02a	5.45a	6.53a	0.20a	7.12a	6.75a	3.85a	0.59a	0*	6.21a	
Years 2010/2011															
Regulska	conventional	before	6.92a	4.79a	0.06a	6.04b	6.50a	1.97ab	7.47a	7.60a	5.41a	0.30a	0.09a	7.20a	
		after	5.50a	3.49a	0.13a	6.67a	6.48a	0.46a	6.56a	5.69a	3.37a	1.12a	0*	4.67a	
	organic	before	7.15a	4.19a	0.06a	4.61a	5.13a	2.41ab	7.23a	7.85a	6.17a	0.05a	0.0a	7.37a	
		after	6.07ab	3.73a	0.0a	6.98a	6.95a	0.23a	5.89a	6.88a	5.57a	0.46a	0*	6.38a	
Perfekcja	conventional	before	6.67a	4.02a	0.05a	4.45a	5.64a	2.75b	6.48a	7.31a	4.71a	0.27a	0.0a	6.20a	
		after	6.37b	3.75a	0.0a	6.67a	6.74a	0.80a	6.33a	6.65a	5.03a	0.73a	0*	6.13a	
	organic	before	6.63a	4.38a	0.28a	6.36b	6.18a	1.53a	7.18a	7.36a	5.42a	0.52a	0.0a	6.71a	
		after	6.15ab	4.10a	0.0a	6.69a	6.39a	0.33a	7.31a	7.50a	5.70a	0.32a	0*	7.18a	

Note: see table 6

After several months of storing and then cooking carrot roots, it was found that the roots of the variety Perfekcja from organic cultivation were characterized by the highest scores for sweet smell and taste, the cooked carrot taste, the best consistency of the flesh, as well as a high overall quality rating (Table 6). In the sensory quality of the cooked carrot roots after storage there was a slight influence of foreign smells, but there was no influence of foreign tastes on the quality of the carrots. Gawęcki and Baryłko-Pikielna (2007) had determined the impact of heat treatment on the changes in the nutritional value, texture, colour, taste and odour of food products. The authors argue that these changes can be beneficial or undesirable, and that their nature depends on the rate, time and temperature of heating, pH of the environment, the presence of inorganic salts and access of air.

CONCLUSIONS

1. Sensory quality of fresh, stored, and heat-treated carrot roots depended on the cultivar and cultivation method.
2. Fresh and stored carrot roots grown in the organic system had higher scores for taste-and-smell attributes than the roots from conventional cultivation.
3. Significant impact on the overall quality of fresh and stored carrot roots of both cultivars was exerted by the intensity of the following quality attributes: the carrot-smell, sweet taste, colour of the outer

skin, and the colour of the longitudinal section of the root.

4. Roots of the carrot variety Regulska received higher scores for most quality attributes, both before and after storage, in comparison with the variety Perfekcja.
5. The overall quality of stored and heat-treated carrot roots was significantly affected by the attributes of the cooked carrot smell, uniformity of skin colour, and stringiness of the flesh.

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JAKOŚĆ SENSORYCZNA MARCHWI POCHODZĄCEJ Z UPRAWY EKOLOGICZNEJ I KONWENCJONALNEJ

Streszczenie

Celem pracy był wpływ sposobu uprawy (ekologiczna i konwencjonalna) na jakość sensoryczną korzeni marchwi świeżej, przechowywanej i poddanej obróbce kulinarnej. Badania były przeprowadzone w laboratorium oceny sensorycznej Instytutu Ogrodnictwa w Skierniewicach w latach 2009-2011. Korzenie marchwi pochodziły z certyfikowanego pola doświadczalnego o ustabilizowanym ekosystemie, przystosowanym do prowadzenia badań nad ekologiczną uprawą warzyw. Jednocześnie w tych samych warunkach glebowo-klimatycznych uprawiano marchew w systemie konwencjonalnym. Materiał badawczy stanowiły dwie odmiany marchwi – Perfekcja i Regulaska. W dwuletnim cyklu wykonano analizę sensoryczną marchwi świeżej, przechowywanej i poddanej obróbce cieplnej. Ocenę sensoryczną wykonał 10-osobowy zespół specjalistów, z wykorzystaniem metody ilościowej analizy opisowej QDA. Wyniki jakościowej oceny sensorycznej i przygotowane na ich podstawie profilogramy dla świeżych i przechowywanych korzeni marchwi wskazują na różnice cech sensorycznych badanych odmian uprawianych w systemie ekologicznym i konwencjonalnym. Największy wpływ na jakość ogólną wywierały wyróżniki: smak typowy dla świeżej marchwi, smak słodki, soczystość i twardość mięszu. Marchew odmiany Regulaska z uprawy ekologicznej charakteryzowała się największą intensywnością smaku słodkiego i typowego dla marchwi oraz najlepszą twardością, chrupliwością, kruchością i soczystością mięszu. W świeżych korzeniach tej odmiany zanotowano najwyższą ocenę ogólną korzeni. Stwierdzono także różnice pod względem niektórych cech sensorycznych w korzeniach marchwi po kilkumiesięcznym okresie przechowania, a następnie po jej ugotowaniu, w zależności od odmiany i sposobu uprawy. W obu latach badań ugotowane korzenie marchwi odmiany Perfekcja z uprawy ekologicznej po okresie przechowania uzyskały najwyższe noty jakości ogólnej. Po przechowaniu i poddaniu obróbce termicznej korzeni marchwi zaobserwowano istotny spadek intensywności większości wyróżników, tj. smaku, zapachu i tekstury w porównaniu do ocenianych korzeni świeżych.