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The influence of cold storage on the quality of carrot cultivars

Wpływ przechowywania w chłodni na jakość korzeni wybranych odmian marchwi

Summary. The influence of long-term storage in cold store conditions on the quality of eight carrot cultivars was investigated. Cultivars chosen for the experiment were – 'Cesaro', 'Jaguar', 'Nelix', 'Perfekcja', 'Recoleta', 'Sirus', 'Teldino', 'Nebula'. The quality was determined in freshly harvested carrots and carrots stored for 8 months. There were determined: weight losses, percentage of carrots with disease symptoms, dry matter content, sugars content, nitrates and nitrites content and sensory quality. Sensory quality was evaluated in the expert panel, with quantitative descriptive analysis (QDA). Of investigated carrot cultivars the lowest storage losses was shown by 'Teldino' – in respect of weight losses, and 'Perfekcja' – in respect of rotting. Storage resulted in changing the content of dry matter, decreasing sugars content but it did not affect nitrates content. The influence of storage on the sensory quality was significant in case of some attributes: firmness, juiciness, bitter taste intensity and, for some cultivars, also sweet taste intensity.

Key words: carrot, quality, sensory analysis, cultivars, cold storage

INTRODUCTION

Carrot (*Daucus carota* L.) is one of several vegetable crops which are grown in temperate climate regions, and are suitable for long-term storage. In Poland most of harvested carrots are stored for at last 3–4 months. Consumption of carrot has increased in recent years, mainly due to a pleasant flavour and high biological value of this vegetable, related to vitamin and dietary fibre content [Alasalvar *et a*l. 2005]. According to USDA database [2004], raw carrot roots contain 12% of dry matter, 4.5% of sugars, 2% of dietary fiber, 5.7 mg 100 g^{-1} of β-carotene, 5.9% of vitamin C. Other data show that carotenoids content is very differentiated among cultivars and varies from 4 to 25 mg 100 g^{-1}, or even more [Rubatzky *et al*. 1999]. Also, sugars content may vary from 4 to 10% f.w.

The main sugar is sucrose, whose amount reaches up to 3.6%. There are many factors affecting the chemical composition of carrots, especially the genotype, growing conditions and storage duration [Warman and Havard 1997]. Genetic variation and environment factors largely influence the quality of carrot, for example the level of volatiles, sugars and carotenoids [Lee 1986, Gills *et al*. 1999, Seljasen *et al*. 2001]. Increasing hexose and decreasing sucrose content was observed during storage of carrots [Suojala 2000]. The bitter taste of stored carrot is caused by accumulation of isocoumarin – 6-methoxymellein [Seljasen *et al*. 2001].

The sensory evaluation of vegetables brings valuable information on their quality characteristics. Sensory traits are usually the main factor determining a consumer's satisfaction [Abbott 1999]. Firmness, sweet taste and absence of bitter or harsh taste are used as the main sensory criteria of carrot quality [Suslow *et al*. 1998]. For a detailed description of sensory characteristics of vegetables the quantitative descriptive analysis (QDA) is applied. In this method an assumption is made that the sensory quality is a complex of many descriptors, which can be individually estimated by a consumer [Meilgaard *et al*. 1999]. For the unification of sensory methods international standards were approved [Sensory analysis ... 1996, 1999]. There are some reports concerning the relationship between sensory quality and physical or chemical characteristics of different vegetable species [Fillion and Kilcast 2002, Gajewski 2003], but there are few reports concerning sensory characteristics of carrot. Haglund *et al*. [1999] found that conventionally grown carrots had a sweeter taste and were crunchier than ecologically grown ones. Hardness, crunchiness, juiciness, sweetness, bitterness, carrot taste and aftertaste were used as the sensory attributes in that experiment. Some correlations between flavour compounds and sensory quality of carrot were found by Varming *at al*. [2004]. However, Martens *et al*. [1983] reported that only 23% of the variation in sensory quality could be predicted by determining the chemical composition of carrot. According to these authors, the consumer's liking for carrot is generally correlated to the perceived sweetness.

The aim of this work was to determine changes of quality parameters, including sensory quality, in carrot cultivars caused by long-term storage in a cold room.

MATERIAL AND METHODS

The two-year experiment was carried out in Warsaw Agricultural University in 2003–2005. Carrot was grown on an experimental field of the University. The soil was a medium mud soil. Fertilizing was applied according to soil analysis results. Carrots were sown directly to the ground at the end of May and plants were harvested at the fully ripen stage, in the middle of September. Marketable quality roots were then stored for 8 months in a cold store, at the temperature of 0–1^{o}C and RH of 95%. The factors for the experiment were:

Factor A – cultivar: eight cultivars were chosen, i.e. 'Cesaro', 'Jaguar', 'Nelix', 'Perfekcja', 'Recoleta', 'Sirus', 'Teldino' and 'Nebula'.

Factor B – term of evaluation: two terms were applied, i.e. immediately after harvest and after 8-months' storage.

All chosen carrot cultivars were late-season cultivars, of orange-colour type, grown in Poland mainly for fresh market. The experiment was done in three replicates. One replicate was one crate with carrots (15 kg).

Immediately after harvest and after storage there were determined: dry matter content (by drying samples at temperature of 105°C to stable weight), total sugars content (by Luff-Schoorl's method) and nitrates content (by spectrophotometric method, with Fiastar device). After storage there were determined: weight losses (in %) and weight percentage of carrots with disease symptoms. All analyses were performed in three replicates.

Sensory analysis was performed in the sensory laboratory, equipped according to ISO standard [Sensory analysis ... 1999]. The trained panel, consisting of 12 persons, previously selected and trained according to ISO standard [Sensory analysis ... 1996], carried out the evaluation. For the evaluation the quantitative descriptive analysis (QDA) was applied.

Table 1. Quality descriptors used in the quantitative descriptive analysis of carrot cultivars
Tabela 1. Wyróżniki jakości zastosowane w ilościowej analizie opisowej odmian marchwi

Descriptor Wyróżniki	Definition Definicja	Anchoring points Punkty skrajne
Flesh firmness Jędrność	Degree of force needed to chew the carrot Stopień siły potrzebnej do gryzienia marchwi	Firm – soft Twarda – miękka
Flesh juiciness Soczystość	Amount of liquid released when chewing a sample Ilość płynu wydzielonego podczas gryzienia próbki	Not juicy – very juicy Niesoczysta – bardzo soczysta
Flesh crunchiness Kruchość	Mouth feel of carrot crunchiness Poczucie kruchości	Not crunchy – very crunchy Niekrucha – bardzo krucha
Flavour of raw carrot Zapach surowej marchwi	Characteristic flavour of fresh, raw carrot Charakterystyczny zapach świeżej, surowej marchwi	None – very intensive Brak – bardzo intensywny
Sweet taste Słodki smak	Basic taste Podstawowy smak	None – very intensive Brak – bardzo intensywny
Bitter taste Gorzki smak	Basic taste Podstawowy smak	None – very intensive Brak – bardzo intensywny
Off-flavour Smak obcy	Unusual flavour for carrot Smak nietypowy dla marchwi	None – very intensive Brak – bardzo intensywny

At the first part of QDA procedure a 'brainstorming' session was run to select sensory attributes for carrots. The panelists received samples of carrot roots varying in sensory properties and generated a set of texture and flavour/taste descriptors (Tab. 1). The analysis was performed in separate booths, equipped with computers. Every assessor was given randomized samples of carrots. For the assessment, the roots were cut into slices, thickness of 1 cm, and put to small plastic containers, covered with lids. The assessments were marked on non-structural lines with anchoring points, which were shown on the monitors. The results were converted to numerical values (from 0 to 10 units). The analysis was performed during two independent sessions, in two replicates. For coding samples and for initial processing of the data 'Analsens' software was used.

The analysis of variance was performed separately for both terms of evaluation. The influence of storage on quality of carrots was determined using two-way analysis of variance, with cultivar (8) and term of evaluation (2) as the factors for the experiment. For this purpose, Statgraphics Plus 4.1 software was applied. LSD test was used to show which values differed significantly at p = 0.05. Results presented in tables and figures are the means of the two years of study.

RESULTS AND DISCUSSION

Storage losses of carrots are shown in Tab. 2. The lowest weight losses (below 5%) were found for cvs. 'Teldino' and 'Recoleta'. The main reason for weight losses during the storage of vegetables is transpiration process, which depends on relative humidity of the atmosphere and a product surface to the volume ratio. All chosen cultivars had a similar shape of roots, so the differences in weight losses were not so big. The lowest percentage of carrots with disease symptoms were found for 'Perfekcja', and the highest for 'Cesaro'. The main reason for rotting was the development of *Botrytis* sp. fungi, which often occur during storage of carrots [Suslow *et al*. 1998]. Diseases development was on a similar level in both years of the experiment. Cvs. 'Jaguar' and 'Recoleta' showed the highest dry matter content immediately after harvest and 'Teldino' and 'Nebula' – the lowest (Tab. 3). 'Perfekcja', 'Recoleta' and 'Teldino' were the cultivars of the highest dry matter content after storage. Storage resulted in changing of dry matter, and this phenomenon can be explained as the effect of water losses caused by transpiration process.

Table 2. Storage losses of carrots during 8-months storage
Tabela 2. Straty przechowalnicze podczas 8 miesięcy przechowywania

Cultivar Odmiana	Weight losses Ubytek masy %	Rotten carrots Marchew zgniła %
Cesaro	5.56 c	3.41 d
Jaguar	5.45 c	2.14 bc
Nelix	5.22 b	2.22 bc
Perfekcja	4.98 b	1.23 a
Recoleta	4.58 a	2.21 bc
Sirus	4.79 ab	1.89 b
Teldino	4.54 a	2.25 bc
Nebula	5.12 b	2.09 b

Note: values which do not differ according to LSD test at p = 0.05 are marked with the same letters
Uwaga: wartości które nie różnią się według testu LSD przy p = 0,05 są oznaczone tymi samymi literami

Total sugars content differed among the cultivars (Tab. 3). 'Perfekcja' showed the highest sugars content immediately after harvest, but 'Nelix' – after storage. 'Nebula' was the cultivar of the lowest sugars content in both terms of evaluation. Sugars content decreased during storage. Nitrates content in carrots was generally low, but 'Jaguar' and 'Sirus' were the cultivars of the highest nitrates content (Tab. 3). Nitrates content was not significantly affected by storage. Nitrites were not found in any cultivar', in any term.

Table 3. Dry matter, total sugars and nitrates content in carrot cultivars, immediately after harvest and after storage
Tabela 3. Sucha masa, zawartość cukrów ogółem i azotanów w odmianach marchwi bezpośrednio po zbiorze i po przechowywaniu

Factor/Czynnik		Dry matter Sucha masa %	Total sugars Cukry ogółem %	Nitrates Azotany mg NO kg^{-1}
Term/Termin	Cultivar/Odmiana			
Freshly harvested Świeżo zebrane	Cesaro	12.3 ab	6.79 b	40 a
	Jaguar	13.2 b	6.98 b	310 c
	Nelix	12.7 ab	7.48 bc	50 a
	Perfekcja	12.6 ab	9.42 e	40 a
	Recoleta	13.1 b	8.55 d	50 a
	Sirus	12.1 ab	7.87 c	180 b
	Teldino	11.5 a	8.61 d	60 a
	Nebula	11.6 a	5.76 a	50 a
After storage Po przechowaniu	Cesaro	12.6 a	6.06 b	60 a
	Jaguar	13.8 b	6.71 c	230 b
	Nelix	13.5 b	9.01 e	70 a
	Perfekcja	14.3 c	7.87 d	30 a
	Recoleta	14.6 c	7.42 d	50 a
	Sirus	13.4 b	7.59 d	230 b
	Teldino	14.4 c	7.35 d	50 a
	Nebula	13.8 b	5.25 a	80 a
Means for terms Średnia dla terminu	Freshly harvested Świeżo zebrane	12.4 a	7.68 b	98 a
	After storage Po przechowaniu	13.8 b	7.16 a	100 a

Note: values which do not differ according to LSD test at p = 0.05 are marked with the same letters
Uwaga: wartości, które nie różnią się według testu LSD przy p = 0,05 są oznaczone tymi samymi literami

Results of the sensory analysis of carrots are shown in Fig. 1–7. Firmness of carrots is a very important quality parameter, relating to their mechanical properties. According to Martens *et al.* [1983] and Filion and Kilcast [2002], firmness of carrots is moderately related to dry matter. Significant differences in firmness at the first term of evaluation were found for 'Cesaro' (the least firm cultivar) and 'Nelix' (the most firm one), and at the second term for 'Sirus' and 'Nelix' (Fig. 1). Generally, storage caused a tendency of decreasing the firmness, but significant differences for the first and the second term of evaluation were showen only by 'Perfekcja' and 'Sirus'. 'Teldino' was the least juicy cultivar immediately after harvest, and 'Jaguar' – the most juicy (Fig. 2). After storage the least juicy was 'Cesaro' and the most juicy – 'Recoleta'. All cultivars were rated as less juicy after storage than the freshly harvested ones, but for 'Teldino' the difference was non-significant. There was found differentiation in crunchiness between cultivars, and 'Cesaro', 'Recoleta' and also 'Nebula' were scored as the least crunchy cultivars in both terms of evaluation, and 'Perfekcja' – as the most crunchy (Fig. 3). The storage caused a significant decrease of crunchiness, with an exception of 'Sirus' and 'Teldino'.

'Flavour of raw carrots' is a complex attribute, and a result of presence of many chemical components – non-volatile and volatile ones. From non-volatile components sugars are the most important components for 'raw carrots flavour' [Martens *et al*. 1983]. Volatile components of raw carrots consist mainly of mono- and sesquiterpenes, and these compounds may change during storage [Varming *et al*. 2004]. At the beginning, all cultivars showed only small differences in 'flavour of raw carrots' intensity (Fig. 4). After storage, these differences were bigger, and the lowest scores for this attribute were given to 'Cesaro', 'Jaguar' and 'Nebula' cultivars. With an exception of 'Teldino', storage caused a significant decrease of 'flavour of raw carrot' intensity.

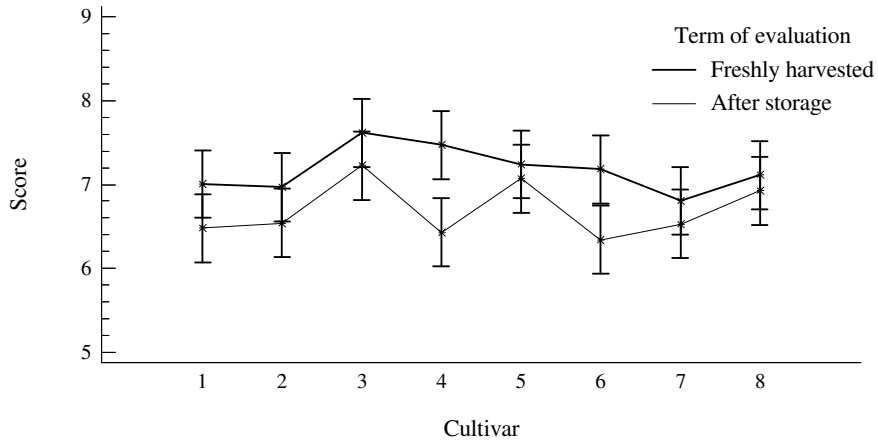

Fig. 1. Sensory evaluation of carrot cultivars – flesh firmness (score 0–10). Bars show LSD at p = 0.05. 1 – 'Cesaro', 2 – 'Jaguar', 3 – 'Nelix', 4 – 'Perfekcja', 5 – 'Recoleta', 6 – 'Sirus', 7 – 'Teldino', 8 – 'Nebula'

Rys. 1. Ocena sensoryczna odmian marchwi – jędrność (0–10). Pionowe linie pokazują LSD przy p = 0,05

Sweet taste in carrot is a result of the presence of sugars, mainly hexoses and saccharose [Warman and Havard 1997]. Varming *et al*. [2004] found very weak correlations between sweetness or bitterness and consumer's liking of carrots. However, Talcott *et al*. [2001] reported that a high sensory quality and sweetness of carrot positively correlate with sugar content. In this experiment the sweet taste was quite strictly related to sugars content, and the sweetest cultivar 'Perfekcja' also had the highest sugars content. Sweet taste intensity was the lowest for 'Nebula' at the first term of evaluation and also at the second term. It corresponds with the lowest sugars content which was found in this cultivar. After storage most carrots cultivars were scored as less sweet than immediately after harvest, with the exception of 'Teldino'. This result is understandable because a of decreasing tendency of sugars content during storage, which was found in this experiment, and was also reported by other authors [Suojala 2000].

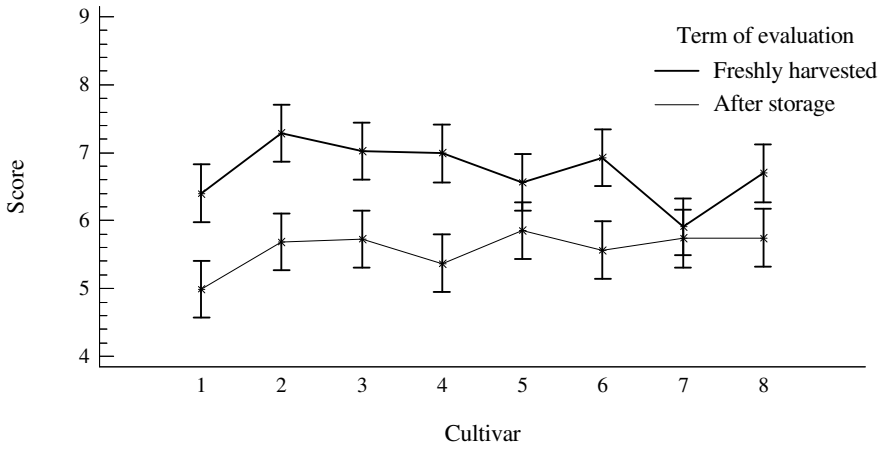

Fig. 2. Sensory evaluation of carrot cultivars – flesh juiciness (score 0–10). Bars show LSD at p = 0.05. 1 – 'Cesaro', 2 – 'Jaguar', 3 – 'Nelix', 4 – 'Perfekcja', 5 – 'Recoleta', 6 – 'Sirus', 7 – 'Teldino', 8 – 'Nebula'

Rys. 2. Ocena sensoryczna odmian marchwi – soczystość (0–10). Pionowe linie pokazują LSD przy p = 0,05

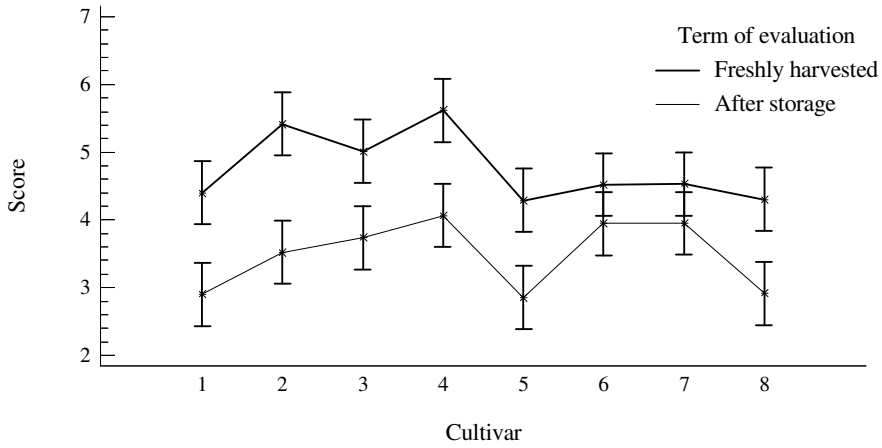

Fig. 3. Sensory evaluation of carrot cultivars – flesh crunchiness (score 0–10). Bars show LSD at p = 0.05. 1 – 'Cesaro', 2 – 'Jaguar', 3 – 'Nelix', 4 – 'Perfekcja', 5 – 'Recoleta', 6 – 'Sirus', 7 – 'Teldino', 8 – 'Nebula'

Rys. 3. Ocena sensoryczna odmian marchwi – chrupkość (0–10). Pionowe linie pokazują LSD przy p = 0,05

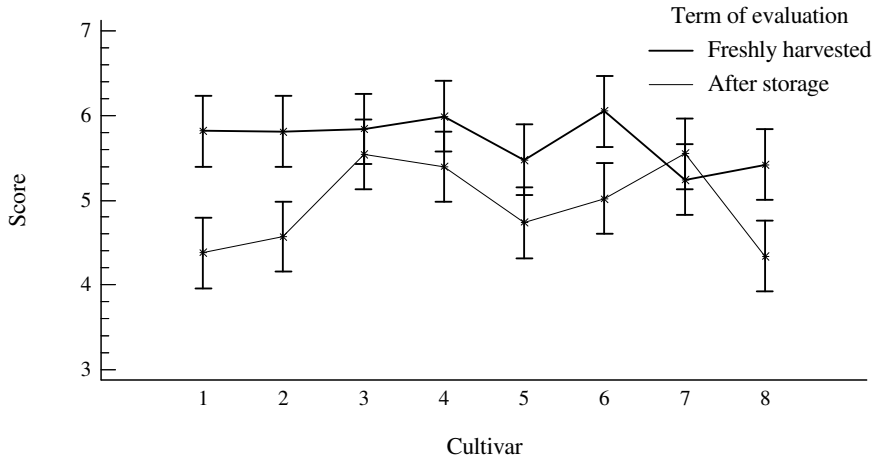

Fig. 4. Sensory evaluation of carrot cultivars – flavour of raw carrot (score 0–10). Bars show LSD at p = 0.05. 1 – 'Cesaro', 2 – 'Jaguar', 3 – 'Nelix', 4 – 'Perfekcja', 5 – 'Recoleta', 6 – 'Sirus', 7 – 'Teldino', 8 – 'Nebula'

Rys. 4. Ocena sensoryczna odmian marchwi – smak surowej marchwi (0–10). Pionowe linie pokazują LSD przy p = 0,05

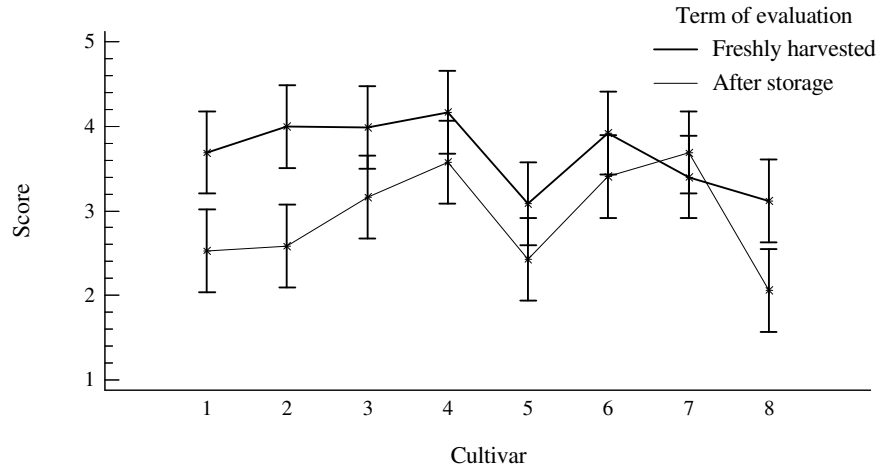

Fig. 5. Sensory evaluation of carrot cultivars – sweet taste (score 0–10). Bars show LSD at p = 0.05. 1 – 'Cesaro', 2 – 'Jaguar', 3 – 'Nelix', 4 – 'Perfekcja', 5 – 'Recoleta', 6 – 'Sirus', 7 – 'Teldino', 8 – 'Nebula'

Rys. 5. Ocena sensoryczna odmian marchwi – słodki smak (0–10). Pionowe linie pokazują LSD przy p = 0,05

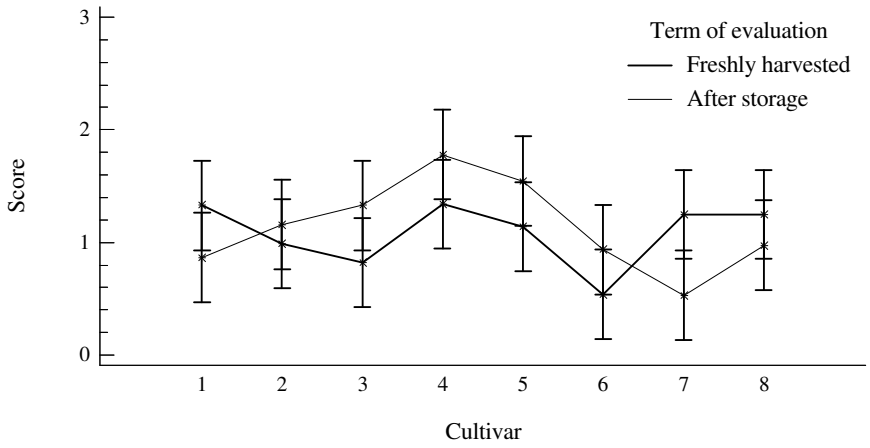

Fig. 6. Sensory evaluation of carrot cultivars – bitter taste (score 0–10). Bars show LSD at p = 0.05. 1 – 'Cesaro', 2 – 'Jaguar', 3 – 'Nelix', 4 – 'Perfekcja', 5 – 'Recoleta', 6 – 'Sirus', 7 – 'Teldino', 8 – 'Nebula'
Rys. 6. Ocena sensoryczna odmian marchwi – gorzki smak (0–10). Pionowe linie pokazują LSD przy p = 0,05

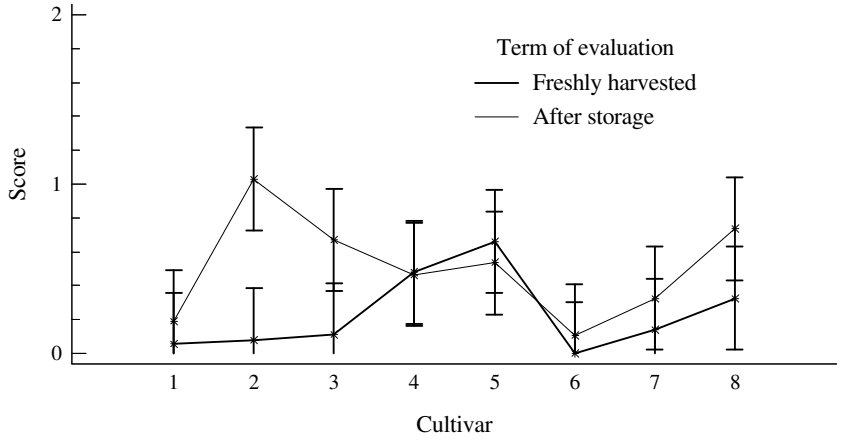

Fig. 7. Sensory evaluation of carrots – off-flavour (score 0–10). Bars show LSD at p = 0.05. 1 – 'Cesaro', 2 – 'Jaguar', 3 – 'Nelix', 4 – 'Perfekcja', 5 – 'Recoleta', 6 – 'Sirus', 7 – 'Teldino', 8 – 'Nebula'
Rys. 7. Ocena sensoryczna marchwi – smak obcy (0–10). Pionowe linie pokazują LSD przy p = 0,05

The least bitter cultivar in the first term of evaluation was 'Sirus' and after storage – 'Teldino'. Most cultivars showed a tendency to be more bitter after storage. Especially big differences in the bitter taste intensity between both terms of evaluation were found for 'Teldino'. Increasing bitterness of carrots during the storage period can be explained as an effect of accumulation of bitter chemical compounds in the root tissue. Accumulation of bitter components in carrots during long-term storage was reported by Leja *et al.* [1997] and Seljasen *et al.* [2001]. Off-flavour intensity was rated on a relatively low level immediately after harvest and also after storage. However, storage caused a significant increase of off-flavour intensity, especially in 'Jaguar'.

In the experiment one cultivar of Polish origin was investigated – 'Perfekcja'. This cultivar showed some advantages over other cultivars – good storage ability (it had the lowest rotten roots percentage), high sugars content and low nitrates accumulation and was it very crunchy and sweet in the sensory evaluation. However, the weakness of this cultivar was high accumulation of bitter compounds during the storage.

CONCLUSIONS

1. Out of the investigated carrot cultivars the lowest storage losses was shown by 'Teldino' – in respect of weight losses, and 'Perfekcja' – in respect of diseases development.

2. Sugars content decreased during storage, and at the same time dry matter content in carrots changed due to the transpiration process.

3. Nitrates content in carrots was stable during the storage period.

4. Sensory quality of the investigated carrot cultivars differed in respect of some quality attributes, and storage affected some of these attributes, including juiciness, crunchiness and sweet taste.

REFERENCES

Abbott J. 1999. Quality measurement of fruits and vegetables. Postharvest Biol. Technol. 15, 207–225.

Alasalvar C., Al-Farsi M., Quantick P.C., Shahidi F., Wiktorowicz R. 2005. Effect of chill storage and MAP on antioxidant activity, anthocyanins, carotenoids, phenolics and sensory quality of ready-to-eat shredded orange and purple carrots. Food Chem. 89, 69–76.

Fillion L., Kilcast D. 2002. Consumer perception of crispness and crunchiness in fruits and vegetables. Food Qual. Prefer. 13, 23–29.

Gajewski M. 2003. Sensory and physical changes during storage of zucchini squash (*Cucurbita pepo* var. *giromontina* Alef.). Acta Hortic. 604, 613–618.

Gills L.A., Resurrection A.V.A., Hurst W.C., Reynolds A.E., Pathak S.C. 1999. Sensory profiles of carrot (*Daucus carota* L.) cultivars grown in Georgia. Hort. Sci. 34, 625–628.

Haglund A., Johansson L., Berglund L., Dahlstedt L. 1999. Sensory evaluation of carrots from ecological and conventional growing systems. Food Quality Pref. 10, 23–29.

Lee C. 1986. Changes in carotenoid content of carrots during growth and post-harvest storage. Food Chem. 20(4), 285–293.

Leja M., Stodolak B., Mareczek A., Rożek S., Wojciechowska R. 1997. Effect of post-harvest storage on metabolism of phenol compounds in carrot root. Folia Hortic. 9/2, 59–69.

Martens M., Fjeldsen B., Russwurm H., Martens H. 1983. Relationship between sensory and chemical quality criteria for carrots, studied by multivariate data analysis. [In:] A. Williams and R. Atkin (eds.) Sensory Quality in Foods and Beverages. Chichester. Ellis Horwood Ltd. 233–246.

Meilgaard M., Civille G. V., Carr B.T. 1999. Sensory Evaluation Techniques. 3rd ed., CRC Press. Boca Raton, London.

Rubatzky V.E., Quiros C.F., Simon P.W. 1999. Carrots and Related Vegetable *Umbelliferae*. CABI, 22–30.

Seljasen R., Bengtsson G., Hoftun H., Vogt G. 2001. Sensory and chemical changes in five varieties of carrot in response to mechanical stress and postharvest. J. Sci. Food Agric. 81, 436–447.

Sensory analysis. Experts. PN–ISO 8586–2, 1996.

Sensory analysis. Methodology. PN–ISO 6564, 1999.

Suojala T. 2000. Variation in sugar content and composition of carrot storage roots at harvest and during storage. Sci. Hort., 1–19.

Suslow T., Mitchell J., Cantwell M. 1998. Carrot. Produce facts. www.postharvest.ucdavis.edu.

Talcott S.T., Howard L.R., Brenes C.H. 2001. Factors contributing to taste and quality of commercially processed strained carrots. Food Res. Int., 34, 31–38.

USDA Nutritional Database for Standard Reference. 2004, Release 17, 270–271.

Varming C., Jensen K., Moller S., Brockhoff P.B., Christiansen T., Edelenbos M., Bjorn G.K., Poll L. 2004. Eating quality of raw carrots – correlations between flavour compounds. sensory profiling analysis and consumer liking test. Food Quality Pref., 531–540.

Warman P.R., Havard K.A. 1997. Yield, vitamin and mineral contents of organically and convencionally grown carrots and cabbage. Agric. Ecosystems Envir. 61, 155–162.

Streszczenie. Badano wpływ długotrwałego przechowywania w warunkach chłodniczych na jakość korzeni ośmiu odmian marchwi. Odmiany użyte w doświadczeniu to: ‘Cesaro’, ‘Jaguar’, ‘Nelix’, ‘Perfekcja’, ‘Recoleta’, ‘Sirus’, ‘Teldino’, ‘Nebula’. Jakość marchwi określano bezpośrednio po zbiorze i po 8 miesiącach przechowywania w chłodni. Określano: ubytek masy, udział marchwi z objawami chorobowymi, zawartość suchej masy, zawartość cukrów, azotanów i azotynów oraz jakość sensoryczną. Jakość sensoryczną oceniano w zespole ekspertów, z wykorzystaniem metody ilościowej analizy opisowej (QDA). Z badanych odmian marchwi najniższe straty przechowalnicze stwierdzono u odmiany ‘Teldino’ – pod względem ubytków masy, oraz u odmiany ‘Perfekcja’ – pod względem udziału korzeni z objawami chorobowymi. Przechowywanie spowodowało zmiany zawartości suchej masy w korzeniach na skutek transpiracji, zmniejszenie się zawartości cukrów, natomiast nie wpłynęło na zawartość azotanów. Wpływ przechowywania na jakość sensoryczną okazał się istotny w przypadku takich wyróżników, jak jędrność, soczystość, intensywność smaku gorzkiego, a u niektórych odmian także intensywność smaku słodkiego.

Słowa kluczowe: marchew, analiza sensoryczna, odmiany, chłodnia