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EFFECT OF FOLIAR MAGNESIUM FERTILISATION AND STORAGE ON SOME PARAMETERS OF THE NUTRITIVE VALUE OF CARROT STORAGE ROOTS

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Abstract

The nutritive value and wholesomeness of carrot are highly appreciated owing to such biologically active compounds as carotenoids, vitamin C and mineral compounds found in its roots.

In 2007-2009, field experiments were performed on the effect of foliar fertilisation of carrot with magnesium sulphate during its vegetative growth on selected nutrients (total carotenoids, vitamin C, mineral magnesium). The field experiment was set up in a split-plot design with three replications on light soil, of slightly acid reaction, low in available P and K forms and very low in Mg. Magnesium was applied in rates of 0, 45 and 90 kg MgO ha^{-1} by spraying carrot plants with a 3% solution during their intensive growth in the vegetative season, accompanied by constant N, P, K fertilisation. The experiment involved five carrot cultivars: medium-late Berjo, and late Flacoro, Karotan, Koral and Perfekcja, all characterized by good storage life. The content of selected nutrients in carrot roots was determined immediately after harvest and after six-month storage in a traditional earthen mound.

Foliar application of magnesium significantly increased the nutritive value of roots of the carrot cultivars after harvest, raising the content of total carotenoids, vitamin C and magnesium in edible parts. The rate of 45 kg MgO ha^{-1} was most favourable. The six-month root storage led to a decrease in the biologically active compounds. The recorded loss (mean for cultivars and fertilisation) reached 20% of carotenoids, 50% of vitamin C

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and 1% of magnesium. The highest nutritive value was determined for roots of the cultivars Karotan and Perfekcja and the lowest one in roots of cv. Flacoro.

Key words: carotenoids, vitamin C, magnesium, carrot cultivars, magnesium fertilisation, storage.

WPŁYW DOLISTNEGO DOKARMIANIA MAGNEZEM I PRZECHOWYWANIA NA WYBRANE PARAMETRY WARTOŚCI ODŻYWCZEJ KORZENI SPICHRZOWYCH MARCHWI

Abstrakt

Wartość odżywcza i zdrowotna marchwi jest wysoko ceniona za względu na występujące w jej korzeniach związki biologicznie czynne, jak karotenoidy, witamina C, oraz związki mineralne.

W latach 2007-2009 przeprowadzono doświadczenia polowe dotyczące wpływu dolistnego dokarmiania marchwi siarczanem magnezu w okresie jej wegetacji na wybrane składniki odżywcze (sumę karotenoidów, witaminę C, magnez mineralny). Doświadczenie polowe założono w układzie zależnym split-plot w 3 powtórzeniach na glebie lekkiej o odczynie lekko kwaśnym, małej zasobności w przyswajalne formy P i K oraz bardzo małej zasobności w Mg. Nawożenie magnezem zastosowano w dawkach 0, 45 i 90 kg MgO ha^{-1} – w formie oprysku 3% roztworem w okresie intensywnego wzrostu roślin w trakcie sezonu wegetacyjnego na tle stałego nawożenia N, P, K. Obiektem badań było 5 odmian marchwi: średnio późna Berjo oraz późne: Flacoro, Karotan, Koral, Perfekcja – o dobrej trwałości przechowalniczej. Zawartość wybranych składników w korzeniach marchwi oznaczono bezpośrednio po zbiorze i po 6 miesiącach przechowywania w kopcu tradycyjnym.

Dolistne nawożenie magnezem wpłynęło istotnie na wzrost wartości odżywczej korzeni badanych odmian marchwi bezpośrednio po zbiorze wskutek zwiększenia w częściach jadalnych zawartości sumy karotenoidów, witaminy C oraz magnezu. Najkorzystniejsza okazała się dawka 45 kg MgO ha^{-1}. Po 6 miesiącach przechowywania korzeni stwierdzono zmiejszenie zawartości związków biologicznie czynnych. Wystąpiły straty (średnio dla odmian i nawożenia) 20% karotenoidów, 50% witaminy C i 1% magnezu. Największą wartość odżywczą miały korzenie odmian Karotan i Perfekcja, a najmniejszą Flacoro.

Słowa kluczowe: karotenoidy, witamina C, magnez, odmiany marchwi, nawożenie magnezem, przechowywanie.

INTRODUCTION

Carrot (*Daucus carota* L.) is one of the key vegetables grown in Asia and Europe. With the carrot yield of 270-300 dt ha^{-1}, Poland is the second European producer (GAJEWSKI et al. 2007). In 2009, the carrot consumption was 21.4 kg per person, including fresh carrot consumption of about 10 kg, which shows how important this vegetable is in human nutrition, as the total annual consumption of vegetables is about 115-120 kg per capita. Most of the carrot harvest supplies the Polish market, although because of the large scale of production and a growing demand, the vegetable has become an important export commodity (FILIPIAK, MACIEJCZAK 2010).

Over the recent years, much attention has been paid to the presence of natural antioxidants found in food, which inhibit or delay the oxidation of other molecules and protect the cells from harmful action of reactive oxygen forms. Fruit and vegetables, e.g. carrot, are rich sources of antioxidants such as carotenoids and phenolic compounds as well as ascorbic acid (Velioglu et al. 1998, Paulauskiene et al. 2006, Podsędek 2007, Pokluda 2008, Domaradzki et al. 2010). With different sowing dates, high yields as well as good storage life, carrot roots are available on the market all year. The quality of storage roots in carrot is cultivar-specific and depends on climate and soil conditions, agronomic practice as well as environmental conditions during prolonged storage (Seljasen et al. 2001, Karkleliene et al. 2009, Domaradzki et al. 2010).

There is relatively much information on the effect of organic and basic mineral (N, P, K) fertilisation on the chemical composition of carrot roots, but little is known about the effect of Mg fertilisation on transformations in carrot roots (Smoleń, Sady 2007). Magnesium participates in the synthesis of carbohydrates, proteins and provitamin A. It is also a structural component of chlorophyll. Therefore, it can be assumed that supplying carrot with such an important macronutrient can affect the accumulation of chemical compounds and their transformations in its roots.

The aim of the present research has been to determine the effect of foliar fertilisation of plants with magnesium as well as of long-term storage on selected parameters of the nutritive value of roots in selected carrot cultivars.

MATERIAL AND METHODS

The research material was obtained from a field experiment carried out at the Experimental Station in Mochełek (2007-2009), owned by the Faculty of Agriculture and Biotechnology, the University of Technology and Life Sciences in Bydgoszcz (the Kujawy and Pomorze Province). The field experiment was performed on light soil of slightly acid reaction, low in available P and K forms as well as a very low in Mg (Table 1).

The experiment was set up in a split-plot design with three replications. The experiment design covered:

- date of analysis (after harvest, after storage);
- cultivars (medium-late Berjo, late Flacoro, Karotan, Koral and Perfekcja);
- magnesium rates (0, 45, 90 kg MgO ha^{-1}) in the form of magnesium sulphate (16%) alongside constant fertilisation with nitrogen (70 kg N ha^{-1}), phosphorus (80 kg P_2O_5 ha^{-1}) and potassium (100 kg K_2O ha^{-1}). Foliar fertilisation with magnesium was applied twice during the intensive plant growth (July, August) with a 3% solution of magnesium sulphate in the rate of 300 dm^3 ha^{-1}.

Table 1

Chemical composition of soil prior to the experiment

Parameter	Unit	Growing year			Richness
		2007	2008	2009	
pH H_2O	-	6.6	6.5	6.7	slightly acid soil
pH KCl	-	6.0	5.9	6.1	
Organic carbon	(mg kg^{-1})	7650	7800	7550	-
Total nitrogen	(mg kg^{-1})	720	690	750	-
Available phosphorus forms	(mg kg^{-1})	24.0	23.0	25.0	low abundance
Available potassium forms	(mg kg^{-1})	42.0	43.0	45.0	low abundance
Available magnesium forms	(mg kg^{-1})	18.5	20.0	17.0	very low abundance

Cultivation treatments and protection against diseases and pests were in line with the requirements established for carrot, i.e. seeds were seed-dressed with Funaben T and the herbicide Stomp 330 EC was applied each year after sowing and prior to plant emergence. During the vegetative period, hand-weeding was performed. Carrot storage roots were harvested at full maturity (first ten days of October). During the harvest, root samples were taken from each plot for analysis and storage studies. The samples were stored in a traditional earthen mound for 6 months. The parameters of the chemical composition of carrot were determined applying the following methods:

– total carotenoids – with the colorimetric method following PN-90/A-75101/12;
– vitamin C – with the titration method following PN-90A-75101/11;
– magnesium – with the atomic absorption method after mineralization.

In the present paper, an attempt has been made to present model determination of daily consumption of total carotenoids, vitamin C and magnesium, assuming that the daily consumption of carrot storage roots equalled 55 g per capita. The data were compared with the Recommended Dietary Allowance. The content of vitamin A was calculated from total carotenoids, assuming 18 mg of carotenoids as equivalent to 1mg retinol RE (Retinol Equivalent).

The results of the 3-year research were statistically verified using the analysis of variance. The significance of differences was evaluated with the Tukey's multiple confidence intervals for the significance level of α=0.05. Coefficients of linear correlation between the quality characteristics in carrot were calculated.

RESULTS AND DISCUSSION

Carotenoids and fibre mostly determine the wholesomeness and nutritive qualities of carrot (ALASALVAR et al. 2005, FIK et al. 2008, DOMARADZKI et al. 2010). Carotenoids are red, orange or yellow pigments soluble in plant lipids, and give the characteristic coloration of roots (SKREDE et al. 1997). Present in edible parts of carrot, carotenoid compounds are mostly α- and β-carotene (HOLDEN et al. 1999, MAYER-MIEBACH, SPIESS 2003, NAWIRSKA, KROL 2004). Being a vitamin A precursor (HANDELMAN 2001, NAWIRSKA, KRÓL 2004) and highly active antioxidants, carotenoids are essential in controlling proper functions of the human body (ROCK 1997, VELIOGLU et al. 1998, PAULAUSKIENE et al. 2006, PODSĘDEK 2007). According to HOLDEN et al. (1999), depending on the cultivar, carrot contains from 57 to 84 mg kg^{-1} of fresh weight of carotenoids, while POKLUD (2008) reported that an average content of carotenoids calculated for 28 carrot cultivars was 86.0 ±25.0 mg kg^{-1} of fresh weight, with the lowest concentration of 42.0 mg kg^{-1} for cv. Fuk and the highest one of 168.0 mg kg^{-1} for cv. Kortina. Some other data imply that the content of carotenoids in carrot roots, being cultivar-specific, ranges even more broadly, e.g. from 10 to 140 mg kg^{-1} of fresh weight (GAJEWSKI et al. 2007), from 55.8 to 138.9 mg kg^{-1} of fresh weight (NAWIRSKA, KRÓL 2004) and from 136 to 854 of fresh weight (LACHMAN et al. 2000). In the present research, the results of the content of carotenoids in roots of five carrot cultivars are given in Table 2 and confirm the earlier results reported by the above authors. The analysis of variance showed significant differences in the content of carotenoids between the cultivars. The highest content of this nutrient was found in cv. Karotan: on average 136.1 mg kg^{-1} of fresh weight; the lowest one appeared in cv. Flacoro: 106.8 mg kg^{-1} of fresh weight. Such results correspond to the root coloration since out of all the cultivars, cv. Karotan had roots in the most intensive dark-orange colour, a finding which coincides with the results reported by SKREDE et al. (1997). A similar relationship was reported by GAJEWSKI et al. (2007), who analysed six carrot cultivars and the root colour ranged from yellow (cv. Yellowstone) through orange (cv. Florida) to purple (cv. Purple Haze). These authors claimed that the darker the root colour, the higher the content of carotenoids.

Magnesium fertilisation significantly increased the content of carotenoids in carrot roots of the cultivars (Table 2). The magnesium rates applied during the growing season increased the content of carotenoids in storage roots immediately after harvest, except for cv. Karotan, which – when exposed to the rate of 45 kg MgO ha^{-1} – did not respond with a significant increase of this nutrient. Carotenoid pigments are thought to be stable as in adequately stored plant products their changes are negligible (KOCA, KARADENIZ 2008). They can only undergo oxidation (SELJASEN et al. 2001), which can lead to a decrease in their content and to sensory changes in the stored

plant material, e.g. paler colour, unpleasant flavour and smell. The present results confirm the above, since after 6-month storage a slight decrease in the content of carotenoid was recorded although the determination date did not have a significant effect on any such changes (Table 2). The smallest decrease in the content of carotenoids occurred in roots of cv. Karotan (17.8%), and the biggest one – in roots of vc. Perfekcja (20.5%). Contrary results were reported by KOPAS-LANE and WARTHESEN (1995), KIDMOSE et al. (2004), who found a slight increase in the content of carotenoids after storage. GAJEWSKI et al. (2010) examined 8 carrot cultivars of various root colour and concluded that after 3 months of storage the content of carotenoids in edible parts of the carrot cultivars rose by 19.2%. In the present research, the magnesium rates slightly stimulated the carotenoid loss in carrot storage roots (Figure 1).

Carrot contains relatively small amounts of vitamin C (L-ascorbic acid). Reports on the content of vitamin C in carrot roots provide various results, e.g. 59.0 mg of vitamin C per 1 kg of fresh root weight (HOLDEN et al. 1999), 60.0 mg (WIERZBICKA, KUSKOWSKA 2002) or 65.2-97.8 mg (MAJKOWSKA-GADOMSKA, WIERZBICKA 2010), depending on the cultivar. ALASALVAR et al. (2001), who determined vitamin C in fresh carrot, reported the following results: 53.3 mg in orange, 19.8 mg in yellow and 12.5 mg in white carrot. Different results

Table 2

Content of carotenoids in the fresh weight of carrot roots; means for 2007-2009 (mg kg^{-1})

Date of determination (A)	Cultivars (B)	Fertilisation MgO kg ha^{-1} (C)			Mean
		0	45	90	
After harvest	Berjo	100.7	107.9	114.5	107.7
	Flacoro	98.5	108.9	113.0	106.8
	Karotan	132.3	133.9	142.1	136.1
	Koral	112.8	120.0	124.7	119.2
	Perfekcja	126.2	131.4	137.6	131.7
	mean	114.1	120.4	126.4	120.3
After storage	Berjo	82.7	86.4	94.7	87.9
	Flacoro	80.1	86.9	92.4	86.5
	Karotan	105.9	112.9	116.9	111.9
	Koral	94.7	94.1	101.0	96.6
	Perfekcja	102.9	104.2	106.8	104.6
	mean	93.3	96.9	102.4	97.5
Mean		103.7	108.7	114.4	108.9
$LSD_{\alpha=0.05}$	A = n.s.*	B = 16.8		C = 2.8	
	B/A = n.s.	A/B = n.s.		C/A = n.s.	
	A/C = n.s.	C/B = n.s.		B/C = n.s.	

*n.s. – no significant difference

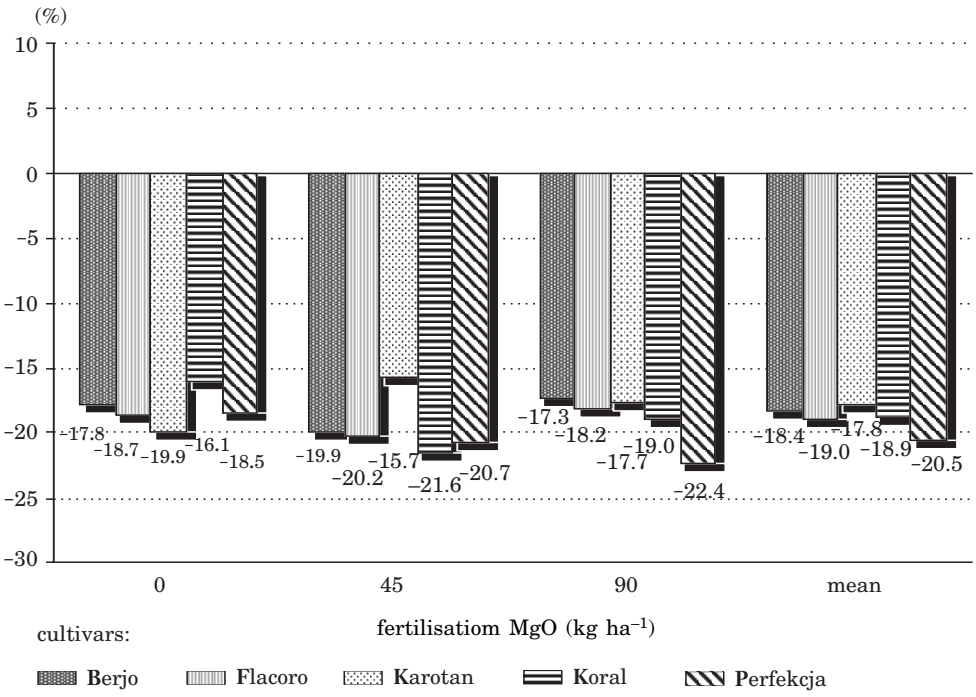

Fig. 1. Percent loss of carotenoids in carrot roots depending on the cultivar, fertilisation and storage period; means for years 2007-2009

were noted by FAVELL (1998), who claimed that the content of vitamin C in fresh weight ranged from 28.0 to 45.0 mg. The present research showed that vitamin C in roots after harvest ranged from 91.1 to 107.4 mg kg^{-1} of fresh weight (Table 3), being slightly higher than reported by the cited authors. This may have been caused by the foliar fertilisation of plants with magnesium. The magnesium rate of 45 kg MgO ha^{-1} increased the content of vitamin C in carrot roots after harvest, as compared with the control, by an average of 13.9% (Table 3). MAJKOWSKA-GADOMSKA and WIERZBICKA (2010), while studying various carrot cultivars and the effect of additional plant fertilisation, recorded a lower content of vitamin C in roots in cv. Deep Purple and Purple Haze but a higher one in cv. Florida after an application of multicomponent fertiliser Crop Care in a dose of 30 kg per ha The same authors, and likewise ALASALVAR et al. (2001), observed that storage roots of the more colour-saturated cultivars contained more ascorbic acid. In the present research, the content of vitamin C was higher in storage roots of the cultivars with the most intensive red colour: cv Karotan had on average of 107.1 mg of vitamin C per kg^{-1} of fresh weight (Table 3). ROGOZIŃSKA et al. (2005) in their earlier experiment with another vegetable (potato), recorded similar effects when applying identical magnesium fertiliser rates as in the

Table 3

Content of vitamin C in the fresh weight of carrot roots; means for 2007-2009 (mg kg^{-1})

Date of determination (A)	Cultivars (B)	Fertilisation MgO kg ha^{-1} (C)			Mean
		0	45	90	
After harvest	Berjo	91.8	90.6	90.8	91.1
	Flacoro	88.0	102.0	93.3	94.4
	Karotan	94.6	117.9	108.8	107.1
	Koral	89.2	105.9	112.0	102.4
	Perfekcja	84.2	94.0	98.4	92.2
	mean	89.6	102.1	100.7	97.4
After storage	Berjo	49.0	48.8	49.0	48.9
	Flacoro	52.1	55.9	59.9	56.0
	Karotan	49.3	44.2	56.9	50.1
	Koral	49.7	51.7	51.9	51.1
	Perfekcja	50.6	53.2	58.8	54.2
	mean	50.1	50.8	55.3	52.1
Mean		69.9	76.4	78.0	74.8
$LSD_{\alpha=0.05}$	A = 17.3	B = n.s.*		C = 5.8	
	B/A = n.s.	A/B = n.s.		C/A = 8.2.	
	A/C = 18.0	C/B = n.s.		B/C = n.s.	

*n.s. – no significant difference

present research,. The most favourable rate was 45 kg MgO ha^{-1}, for which the content of vitamin C in potato tubers was the highest.

Vitamin C is the least stable nutrient and can be destroyed by ultraviolet radiation, high temperatures, the presence of oxygen, oxidation enzymes, metal ions and long-term storage (Wierzbicka, Kuskowska 2002, Gąsiorowska, Markiewicz 2004, Domaradzki et al. 2010). Gąsiorowska and Markiewicz (2004) demonstrated a linear dependence between the vitamin C content and the storage period in another vegetable (potato). According to the above authors, the longer the storage period, the higher the vitamin C loss. It is also common knowledge that the content of vitamin C benefits from low but stable temperature. The present study confirms such dependence since carrot storage roots were stored in an earthen mound, in which maintaining stable temperature is very difficult. After long storage (6 months) a very high vitamin loss was reported: from 40.6 to 52.7% on average (Figure 2). The highest vitamin C loss was reported in cv. Karotan (62.5%) fertilised with 45 kg MgO ha^{-1} and the lowest one in cv. Flacoro (35.8%) which received 90 kg MgO ha^{-1}. Nawirska and Król (2004) recorded a very low vitamin C content after 60 days of storage of 4 carrot cultivars: from 16.0 mg in cv. Nantejska to 24.5 mg kg^{-1} of fresh weight in cv. Flacoro. As reported

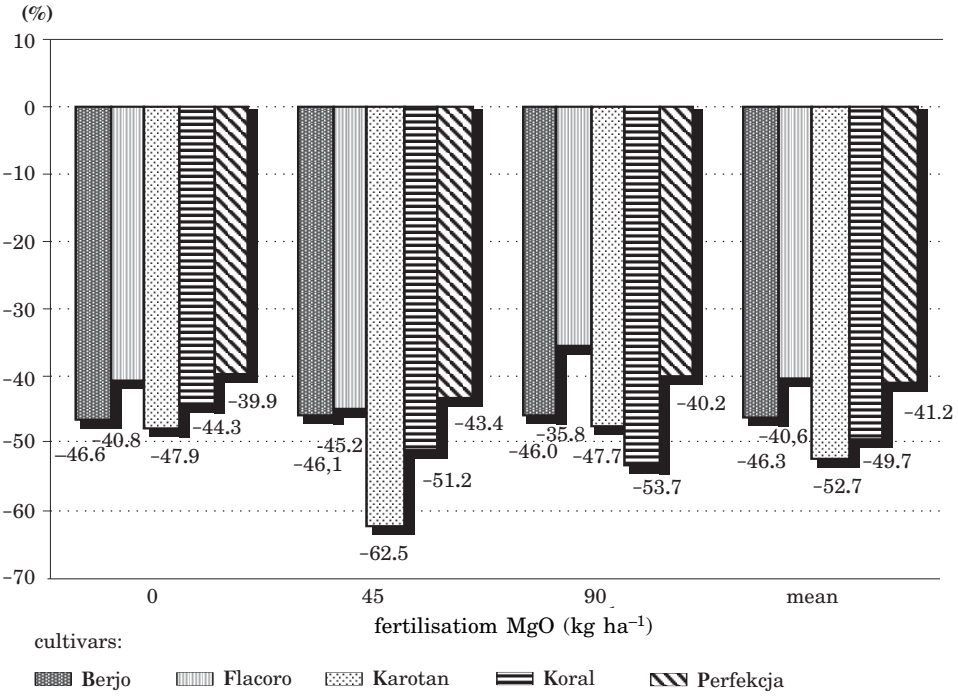

Fig. 2. Percent loss of vitamin C in carrot roots depending on the cultivar, fertilisation and storage period; means for years 2007-2009

by WIERZBICKA and KUSKOWSKA (2002), vitamin C loss after 60 days of storage ranged from 12.9% to 52.8% in 20 different vegetables, including carrot. Magnesium is an element which is not readily absorbable from our diet (just 50% of magnesium in food is absorbed). On the other hand, since magnesium partakes in most biochemical processes in the body, it can be perceived as one of the most essential cell cations; hence the importance of the presence of magnesium in food products. The results of our analyses on the magnesium content in dry matter of five carrot cultivars are given in Table 4. The cultivars did not differ significantly in their magnesium content. MAJKOWSKA-GADOMSKA and WIERZBICKA (2010), who examined three other cultivars than the ones discussed here, recorded contrary results. Interestingly, the average content of magnesium in the dry matter of carrot roots was much higher in the present research (1.79 g kg^{-1}) than reported by MAJKOWSKA-GADOMSKA and WIERZBICKA (2010), which was 1.0 g kg^{-1}. Such a big difference must have been induced by the positive effect of foliar fertilisation of carrot with magnesium sulphate. The authors cited above also applied additional fertilisation (multicomponent fertiliser Crop Care, containing magnesium). However, they did not record any significant effect of this fertiliser on the content of magnesium in carrot roots. In the present research, the statistical analysis showed that the magnesium fertilisation rate

Table 4

Content of magnesium in the dry weight of carrot roots; means for 2007-2009 (mg kg^{-1})

Date of determination (A)	Cultivars (B)	Fertilisation MgO kg ha^{-1} (C)			Mean
		0	45	90	
After harvest	Berjo	1.72	1.83	1.99	1.85
	Flacoro	1.53	1.75	1.89	1.72
	Karotan	1.53	1.70	1.99	1.74
	Koral	1.46	1.81	2.04	1.77
	Perfekcja	1.74	1.76	2.12	1.87
	mean	1.60	1.77	2.01	1.79
After storage	Berjo	1.70	1.82	1.97	1.83
	Flacoro	1.51	1.74	1.88	1.71
	Karotan	1.52	1.68	1.97	1.72
	Koral	1.44	1.79	2.02	1.75
	Perfekcja	1.73	1.74	2.10	1.86
	mean	1.58	1.75	1.99	1.77
Mean		1.59	1.76	2.00	1.78
$LSD_{\alpha=0.05}$	A = n.s B/A = n.s. A/C = n.s	B = n.s. A/B = n.s. C/B = 0.14		C = 0.07 C/A = n.s. B/C = 0.23	

*n.s. – no significant difference

had a significant effect of on the content of this element in carrot roots. As expected, each rate applied increased the content of magnesium in the dry matter of roots. The rate of 45 kg MgO ha^{-1} resulted in a 10.6% increase in magnesium content and the rate of 90 kg MgO ha^{-1} raised it by 25.8%, as compared with the control.

Minerals, including magnesium, demonstrate high thermal stability and, as such, they do not undergo extensive modifications. The present research confirms high stability of this cation in that the magnesium loss during storage was negligible, varying from 0.8% to 1.2% on average (Figure 3).

Numerous studies emphasise the positive effect of a diet rich in vegetables on human health. According to various sources, vegetable consumption should be about 500 g served with 4-5 meals a day. Since carrot is one of the most popular vegetables, this study has included an attempt at defining daily consumption of the total carotenoids, vitamin C and mineral magnesium, assuming that the average consumption of carrot was 55g per person a day (Table 5). By comparing the present data with the norm contained in the Recommended Dietary Allowance, it can be concluded that the daily requirement for vitamin C and magnesium will not be covered much by eating 55 g of carrot a day, but the daily consumption of carotenoids will be

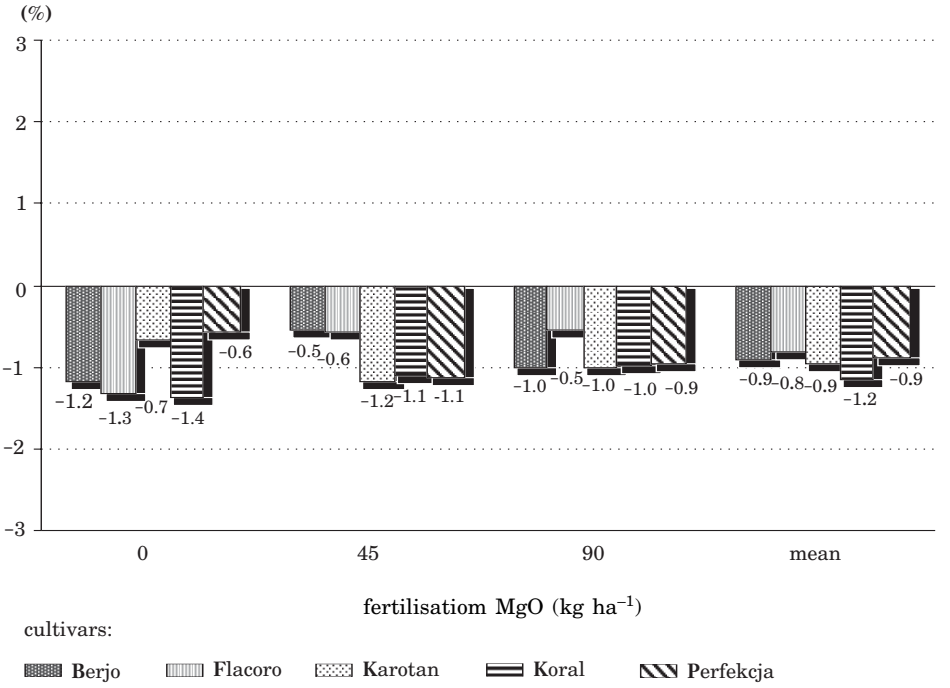

Fig. 3. Percent loss of magnesium in carrot roots depending on the cultivar, fertilisation and storage period; means for years 2007-2009

considerable. Converting the total carotenoids into vitamin A, on the assumption that 18 mg of carotenoids is equivalent to 1mg of retinol RE (Retinol Equivalent), the daily intake of vitamin A equals 43% of the required amount when eating 55 g of carrot right after harvest and 35 % when eating the same amount of stored carrot.

The results of our analysis of the linear correlation are given in Tables 6 and 7. As seen from Table 6, positive correlation between the content of vitamin C and the content of carotenoids in carrot roots appeared (r=0.50), whereas after storage (Table 7) vitamin C correlated positively with the content of magnesium, which means that the higher the content of vitamin C in carrot roots, the higher the content of carotenoids directly after harvest and magnesium after 6 months of storage.

Table 5

Daily nutrient requirements covered by consumption of 55 g of carrot daily* – mean for cultivars in 2007-2009

Dose of MgO (kg ha^{-1})	Carotenoids				Vitamin C				Magnesium			
	content (mg kg^{-1} fr.m.)		consumption (µg day^{-1})		content (mg kg^{-1} fr.m.)		consumption (mg day^{-1})		content (mg kg^{-1} fr.m.)		consumption (mg day^{-1})	
	1	2	1	2	1	2	1	2	1	2	1	2
0	114.1	93.3	6275	5129	8.96	5.01	0.49	0.28	202.4	204.3	11.13	11.24
45	120.4	96.9	6623	5328	10.21	5.08	0.56	0.28	230.6	235.4	12.68	12.95
90	126.4	102.4	6951	5631	10.07	5.53	0.55	0.30	268.1	271.6	14.75	14.94

*mean consumption of fresh and processed carrot (without juices) in Poland is 20 kg year^{-1} per capita.
1 – after harvest, 2 – after storage (6 months)

RDA (Recommended Dietary Allowance): Vitamin C – 90 mg day^{-1}
Vitamin A – 900 µg day^{-1}
Magnesium – 350 mg day^{-1}

Table 6

Significant correlation coefficients (r) between the analysed characteristics determined after harvest

Characteristics		2.	3.
1.	Vitamin C content	0.503	
2.	Carotenoids content		
3.	Magnesium content		

$P_{0.05}\ r = 0.497$

Table 7

Significant correlation coefficients (r) between the analysed characteristics determined after storage

Characteristics		2.	3.
1.	Vitamin C content		0.508
2.	Carotenoids content		
3.	Magnesium content		

$P_{0.05}\ r = 0.497$

CONCLUSIONS

The wholesomeness of carrot roots was significantly affected by fertilisation at the rate of 45 kg MgO ha^{-1}. A significant increase in the content of carotenoids, vitamin C and mineral magnesium in the edible parts of carrots appeared after that treatment.

The cultivars differed in their content of nutrients. Irrespective of the experimental factors, the best nutritive value was recorded in roots of cv. Perfekcja and Karotan.

Analysing carrot roots after 6-month storage, on average, an average 19% loss of carotenoids, 46% vitamin C loss and 0.94% magnesium loss were recorded.

Consumption of 55 g a day of the analysed carrot fulfils much of the daily demand for vitamin A but fails to provide the required amounts of vitamin C and magnesium.

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