ACTA *Acta Sci. Pol., Hortorum Cultus 10(4) 2011, 27-35*

THE EFFECT OF $CaCl_2$ FOLIAR TREATMENT (BEFORE HARVEST) ON THE ACCUMULATION OF NITRATES AND NITRITES IN FRESH AND STORED BUTTERHEAD LETTUCE

Katarzyna Olszówka, Irena Perucka
University of Life Sciences in Lublin

Abstract. The leaves of lettuce are very reach source of vitamins, macro and microelements and biologically active compounds. However, these plants contain also anti-nutritional compounds as nitrates and nitrites which levels depend on growth and storage conditions. The aim of this study was to determine the effect of foliar application of $CaCl_2$ treatment before harvest on nitrate and nitrite accumulation, in whole leaves and leaf blades in fresh and stored lettuce. The experimental material was lettuce cv. Omega which was grown in greenhouse. The solution of $CaCl_2$ was used in the concentration of 0.1M and 0.2M on plants, 20 and 10 days before harvest. After harvest, some plants were directly analysed, while the remaining plants were cold-stored at 4ºC for 7 and 14 days in dark polyethylene bags. The higher concentrations of nitrate and nitrite was noticed in fresh whole leaves than in leaf blades. The foliar $CaCl_2$ treatment of plants before harvest contributed to a statistically decrease in the nitrate levels and nitrite increase in whole leaves in fresh plants. The greatest changes were noticed after using of 0.1M $CaCl_2$ solution on plants. During the storage time of lettuce in the non-treatment plants were observed the higher concentration of nitrates and nitrites in leaf blades compared to fresh plants. The $CaCl_2$ treatment on lettuce caused a significant decrease in the nitrite concentration of whole leaves of plants stored for 7 days, while in the leaf blades higher nitrite amounts were accumulated in lettuce which was stored in cold conditions during all experimental time.

Key words: *Lactuca sativa* L., $CaCl_2$ foliar application, NO_3^-, NO_2^-, cold storage

INTRODUCTION

Leaf vegetables are an important component of a balanced diet which promotes the consumption of higher quantities of fruit and vegetables. Nitrate III and V, in slight amounts, are natural components of higher plants and are involved in biochemical and

Corresponding author – Adres do korespondencji: Irena Perucka, Phytochemistry Research Group, Department of Chemistry, University of Life Sciences in Lublin, Akademicka 15, 20-950 Lublin, e-mail: irena.perucka@up.lublin.pl

physiological processes. The presence of nitrates in vegetables and other food products is a serious threat of human health. The harmful effects of nitrates are related to the dangerous compounds that are synthesized in the organism. Approximately 5% of all nitrate is converted in saliva and the gastrointestinal tract to the nitrite [Pannala et al. 2003, Santamaria 2006]. The most serious danger comes from nitrite which is produced by nitrate reduction and which can lead to methaemoglobinemia or form nitrosamines and nitrosamides by reacting with amines and amides that have carcinogenic action [Bruning-Fann and Kaneene 1993, Mensinga et al. 2003, Santamaria 2006]. On the other hand some components of vegetables, ascorbic acid, tocopherols, carotenoids or flavonoids, inhibit the toxic effect of nitrites [Walker 1990, Steinmetz and Potter 1991]. Also mineral components, potassium and calcium present in soil, affect on assimilation and translocation of nitrates in the plant [Ruiz et al. 1999].

There are some suggestions that the protective effect of certain vegetables on the cardiovascular system is related to their high content of inorganic nitrate which in concert with symbiotic bacteria in the oral cavity is converted into nitrite, nitric oxide and secondary reaction products with vasodilating and tissue-protective properties [Lundberg et al. 2006].

The leafy vegetables are the major vehicle for the entry of nitrate into the human system. Van Velzen et al. [2008] in their study show that nitrate is absorbed from leafy vegetables very effectively, resulting in an absolute nitrate bioavailability of around 100%.

The first step in nitrate assimilation in plant – the reduction of nitrate to nitrite, catalyzed by NAD(P)H: nitrate reductase – is highly regulated. In many plant species, leaves are the primary site of nitrate reduction [Ruiz et al. 1999]. A potentially important factor controlling the phosphorylation status of nitrate reductase is cytosolic Ca^{2+} [Huber et al. 1996].

Calcium is considered as an important nutrient for plants and is known to have a rigidifying effect on cell membranes but it is considered necessary for protection against tipburn incidence mainly if perturbations of membranes by supraoptimal levels of active gibberellins are to be prevented [Saure 1998, Michałojć and Szewczuk 2003a, 2003b, Michałojć and Horodko 2006]. It is known to increase the membrane permeability and thus greater availability of other ions to the site of the enzyme action is possible which may cause an indirect regulation of the enzyme activity in the presence of $CaCl_2$ [Bharti et al. 1996] and also may act as inhibitor of nitrate reductase [Ruiz et al. 1999].

Therefore the objective of the present work was to investigate the effect of the foliar application before harvest at different concentrations of $CaCl_2$, on the accumulation of nitrate V and III in whole leaves and leaf blades (leaves without midrib) of fresh and cold-stored lettuce.

MATERIAL AND METHODS

The study involved pot experiment conducted in the years 2006–2007, in spring, in a greenhouse of Department of Cultivation and Fertilization of Horticultural Plants of University of Life Sciences in Lublin. The experimental material comprised lettuce cultivar Omega. Pots with a volume of 2L were filled with peat with pH of 5.4 and limed to pH of 6.4 with calcium carbonate. There was added 4 g of superphosphate, equivalent to 0.8 g of phosphorus, Cu – 26.6 mg, Mn – 10.2 mg, B – 3.2 mg, Mo – 7.4 mg, Zn – 1.48 mg per pot. Before planting and twice after planting: N – 0.75 g, K – 1.5 g and Mg – 0.45 g, totalling in experiment, were added to the pots. Temperature in the greenhouse was maintained at 18ºC at night and 23ºC during the day. The three factors experiment was performed in randomized split-plot method in 5 replications where 1 plant in 1 pot was one replication. Experimental factors were as following: calcium chloride in concentrations 0.1M, 0.2M and control; time of storage 0, 7 and 14 days and parts of plants: whole leaves and leaf blades without midrib. Each group involved 15 plants. Plants were sprayed twice, 20 and 10 days before harvest. After harvest, in the half of the second decade of April, one group was directly analysed, while the second and third were cold-stored at 4ºC for 7 and 14 days in dark polyethylene bags. Plant were washed in deionised water before analysis. Leaf blades without midrib and whole leaves were extracted from each plant, dried at room temperature and grinded. The prepared material was subjected to chemical analyses.

The content of nitrate V and III was determined with usage of Griesse reagent, according to PN-92/A-75112 (neq ISO 6635-1984) and measured at λ = 576 nm on Shimadzu spectrophotometer UV-Vis. The levels of nitrate III and V were calculated on the basis of standard curve and expressed as $mg \cdot kg^{-1}$ f.w. $NaNO_2$ and $NaNO_3$.

Statistical analysis was made by an analysis of variance (ANOVA), using Statgraphics v 3.1 for Windows. Tuckey's test (at a 5% significance level) was used to evaluate the significant differences among the mean values.

RESULTS AND DISCUSSION

Nitrate content in vegetables depends on many factors, such as fertiliser usage, cultivation conditions, vegetation period, storage time [Pennington 1998, Tamme et al. 2006], the edible parts of the analysed vegetable species and depended on the cultivar [Majkowska-Gadomska et al. 2009].

The results obtained in this study indicated that nitrate concentrations differed among of the edible part of leaves of cv Omega (tab. 1). The nitrate level expressed in $NaNO_3$ varied from 1927.66 to 2481.76 $mg \cdot kg^{-1}$ f.w. respectively in leaf blades and whole leaves of fresh control plants. The values are about twice lower than date accepted by Commission Regulation Members States in 2006 for lettuce which was cultivated in greenhouse and harvested from 1 April to 30 September [Gajda-Wyrębek et al. 2009]. The results obtained by Prasad and Chetty [2008] for the content of nitrates in fresh lettuce ranged from 1297 to 5658 $mg \cdot kg^{-1}$, determined as NO_3^--N and were higher than nitrate contents in lettuce assayed by Correia et al. [2010] (1156 $mg \cdot kg^{-1}$). In our experiments the values of 2481.76 $mg \cdot kg^{-1}$ fw expressed as $NaNO_3$, determined for lettuce var. Omega.

The results of this study of $CaCl_2$ foliar treatment on lettuce cv Omega before harvest on nitrate and nitrite accumulations in fresh and stored plants are presented in table 1 and 2.

A statistical analysis showed that the $CaCl_2$ foliar treatment on plant before harvest had a significant effect on nitrate content in the leaves of lettuce (tab. 1).

Table 1. Concentration of nitrates in fresh and stored lettuce cv Omega after $CaCl_2$ foliar treatment (means for 2006–2007)

Tabela 1. Zawartość azotanów w świeżej i przechowywanej sałacie odmiany Omega po traktowaniu dolistnym $CaCl_2$ (średnie z lat 2006–2007)

Analysed part of plant Analizowana część rośliny	$CaCl_2$ concentration (M) $CaCl_2$ stężenie (M)	$NaNO_3$ ($mg \cdot kg^{-1}$ fw) – ($mg \cdot kg^{-1}$ św.m.) storage time (days) okres przechowywania (dni) 0	7	14	mean średnio
Whole leaves Całe liście	0	2481.76	3385.01	2313.06	2726.61
	0.1	1316.40	1939.47	1489.24	1581.70
	0.2	1938.98	2252.39	2348.14	2179.84
	mean – średnio	1912.38	2525.62	2050.15	2162.72
	$LSD_{0.05}$ – $NIR_{0.05}$				
	$CaCl_2$		128.08		
	storage time okres przechowywania		127.50		
	$CaCl_2$ × storage time $CaCl_2$ × okres przechowywania		144.25		
Leaf blades Blaszki liściowe	0	1927.66	2253.56	2407.97	2196.39
	0.1	2453.25	2428.99	2423.71	2435.32
	0.2	2586.07	2180.64	2498.55	2421.75
	mean – średnio	2322.33	2287.73	2443.41	2351.15
	$LSD_{0.05}$–$NIR_{0.05}$				
	$CaCl_2$		160.35		
	storage time okres przechowywania		161.30		
	$CaCl_2$ × storage time $CaCl_2$ × okres przechowywania		208.12		

It was noticed decreasing the nitrate levels in whole leaves of plants treatment with $CaCl_2$ in the concentrations of 0.1M and 0.2M, respectively about 47% and 22%, compared to control. However, in leaf blades these values were higher than in control plants.

Ruiz et al. [1999] in their study with *Nicotiana tabacum* showed that NO_3^- availability in different part of the plant was influenced by $CaCl_2$ treatment. Nitrate was translocated towards the aerial part and subsequently assimilated in the leaves with the treatments 1.25 mM $CaCl_2 \cdot H_2O$ and 2.5 mM $CaCl_2 \cdot H_2O$, the latter significantly intensifying these processes.

As shown by experimental data, nitrate concentrations varied significantly during time storage. The highest concentrations of these compounds were noticed after 7 days of cold storage in whole leaves, and in leaf blades after 14 days in non-treatment plants (tab. 1).

The using $CaCl_2$ foliar treatment on lettuce before harvest influenced on decreasing of nitrate levels in whole leaves during 7 and 14 days of storage plants in cold conditions, but in leaf blades the significant decrease of these compounds was noticed in plants treated with 0.2M $CaCl_2$ only after 7 days of storage (tab. 1).

According to results obtained by Chung et al. [2004] for fourth vegetables refrigerated storage caused nitrate and nitrite values to be largely unaffected during 7 days. In our experiments the foliar $CaCl_2$ treatment on leaves of lettuce caused the lower accumulation of this ion during refrigerated storage in whole leaves, compared to non-treated plants.

Table 2. Concentration of nitrite in fresh and stored lettuce cv Omega after $CaCl_2$ foliar treatment (means for 2006–2007)
Tabela 2. Zawartość azotynów w świeżej i przechowywanej sałacie odmiany Omega po dolistnym traktowaniu $CaCl_2$ (średnie z lat 2006–2007)

Analysed part of plant Analizowana część rośliny	$CaCl_2$ concentration (M) $CaCl_2$ stężenie (M)	$NaNO_2$ ($mg \cdot kg^{-1}$ fw) – ($mg \cdot kg^{-1}$ św.m.) storage time (days) okres przechowywania (dni)			$NaNO_2$ ($mg \cdot kg^{-1}$ fw) – ($mg \cdot kg^{-1}$ św.m.) mean średnio
		0	7	14	
Whole leaves Całe liście	0	0.265	0.318	0.192	0.258
	0.1	0.508	0.245	0.467	0.406
	0.2	0.358	0.183	0.615	0.385
	mean – średnio	0.377	0.248	0.424	0.349
	$LSD_{0.05}$–$NIR_{0.05}$				
	$CaCl_2$		0.020		
	storage time okres przechowywania		0.021		
	$CaCl_2$ × storage time $CaCl_2$ × okres przechowywania		0.028		
Leaf blades Blaszki liściowe	0	0.175	0.265	0.372	0.271
	0.1	0.335	0.389	0.357	0.360
	0.2	0.317	0.341	0.430	0.363
	mean – średnio	0.275	0.332	0.386	0.331
	$LSD_{0.05}$–$NIR_{0.05}$				
	$CaCl_2$		0.030		
	storage time okres przechowywania		0.031		
	$CaCl_2$ × storage time $CaCl_2$ × okres przechowywania		0.041		

The level of nitrite expressed in $NaNO_2$ in the leaf blades was lower than in whole leaves and was in the level 0.175 $mg \cdot kg^{-1}$ f.w. in control fresh plants (tab. 2). In the whole leaves of fresh plants were noticed that $CaCl_2$ treatment caused increasing of nitrite levels depended of doses about 92% and 35%, respectively for 0.1M and 0.2M $CaCl_2$, compared to control fresh plants (tab. 2). During cold storage of plants were noticed increasing nitrite concentrations about 20% after 7 days and after 14 days decreasing about 27.5% compared to control of fresh plants. The using $CaCl_2$ treatment in 0.1M and 0.2M affected on decreasing, respectively, nitrite levels in whole leaves about 23% and 43% compared to non-treatment plants stored during 7 days, but increasing 2.5 and 3.2 times after 14 days stored. The $CaCl_2$ treatment on lettuce caused increasing the nitrite levels also in leaf blades in fresh plants about 91% and 81%, dependence on doses, compared to control. The storage time also influenced on increasing of the nitrite content in leaf blades about 51% after 7 days and 113% after 14 days, compared to fresh untreated plants.

The obtained results were lower than citated in literature for lettuce. In the plants which were assayed by Correia et al. [2010] the mean of nitrite levels was 2.6 $mg \cdot kg^{-1}$ (as NO_2^-). It is assumed that the nitrite levels in fresh leafy vegetables are less than 2 $mg \cdot kg^{-1}$ [Santamaria 2006].

Nitrate accumulation is not necessarily accompanied by simultaneous nitrite accumulation in the edible part of vegetables which were also assayed by others authors [Amr and Hadidi 2001]. The different capacity to accumulate nitrate can correlate with a different location of nitrate – reductase activity as well as to a different degree of nitrate absorption and transfer in the plant. The vegetable organs can be listed by decreasing nitrate content as follows: petiole, leaf, stem, root, tuber, bulb, fruit, seed [Santamaria 2006].

Table 3. Concentration dry matter in fresh and stored lettuce cv Omega after $CaCl_2$ foliar treatment (means for 2006–2007)
Tabela 3. Zawartość suchej masy w świeżej i przechowywanej sałacie odmiany Omega po dolistnym traktowaniu $CaCl_2$ (średnie z lat 2006–2007)

Analysed part of plant Analizowana część rośliny	$CaCl_2$ concentration (M) $CaCl_2$ stężenie (M)	Dry matter (%) Sucha masa (%) storage time (days) okres przechowywania (dni) 0	7	14	mean średnio
Whole leaves Całe liście	0	3.929	3.846	4.050	3.942
	0.1	3.832	3.915	3.435	3.727
	0.2	3.890	3.711	4.163	3.921
	mean – średnio	3.884	3.824	3.883	3.863
	$LSD_{0.05}$–$NIR_{0.05}$				
	$CaCl_2$		0.382		
	storage time okres przechowywania		0.327		
	$CaCl_2$ × storage time $CaCl_2$ × okres przechowywania		0.316		
Leaf blades Blaszki liściowe	0	3.920	4.083	4.113	4.038
	0.1	4.870	4.342	3.988	4.400
	0.2	4.114	4.059	3.984	4.052
	mean – średnio	4.301	4.161	4.028	4.163
	$LSD_{0.05}$ – $NIR_{0.05}$				
	$CaCl_2$		0.324		
	storage time okres przechowywania		0.372		
	$CaCl_2$ × storage time $CaCl_2$ × okres przechowywania		0.404		

According to results obtained by Burns et al. [2011], accumulation of nitrate in different cultivars of butterhead lettuce were negatively correlated with their dry matter contents. In our experiments a similar trends in changes of nitrate concentrations after $CaCl_2$ treatment were noticed in dry matter contents in fresh and stored lettuce in cold conditions, but nonsignificant one (tab. 3).

CONCLUSIONS

1. Nitrate and nitrite content in leaves of lettuce cv Omega depended on doses of $CaCl_2$ foliar treatment, storage time and analysed part of plant.

2. The higher concentrations of these compounds were noticed in fresh whole leaves than in leaf blades.

3. The foliar $CaCl_2$ treatment on plants before harvest contributed to a statistically decrease in the nitrate levels and nitrite increase in whole leaves of fresh plants. The greatest changes were noticed after using $CaCl_2$ in the concentration of 0.1M.

4. In the leaf blades of fresh control plants was found the lower nitrate and nitrite levels than in lettuce after $CaCl_2$ treatment in both concentrations.

5. During the storage time of lettuce in the non-treatment plants were observed the higher concentration of nitrate and nitrite in whole leaves after 7 days, but after 14 days the contents of these compounds decreased and was lower than in fresh plants.

6. The using of $CaCl_2$ treatment on plants caused a significant decrease in the nitrite concentration of whole leaves stored for 7 days, while in the leaf blades higher nitrite amounts than in fresh plants were accumulated in lettuce which was stored in cold conditions during all experimental time.

REFERENCES

Amr A., Hadidi N., 2001. Effect of cultivar and harvest date on nitrate (NO_3) and nitrite (NO_2) content of selected vegetables grown under open field and greenhouse conditions in Jordan. J. Food Comp. Anal., 14, 59–67.

Bharti N., Singh R.P., Sinha S.K., 1996. Effect of calcium chloride on heavy metal induced alteration in growth and nitrate assimilation of *sesamium indicum* seedlings. Phytochem., 41 (1), 105–109.

Bruning-Fann C.S., Kaneene J.B., 1993. The effects of nitrate, nitrite and N-nitroso compounds on human health: a review. Vet. Human. Toxicol., 35, 521–538.

Burns I.G., Zhang K., Turner M.K., Meacham M., Al-Redhiman K., Lynn J., Broadley M.R., Hand P., Pink D., 2011. Screening for genotype and environment effects on nitrate accumulation in 24 species of young lettuce. J. Sci. Food Agric., 91, 553–562.

Chung J.-C., Chou S.-S., Hwang D.-F., 2004. Changes in nitrate and nitrite content of four vegetables during storage at refrigerated and ambient temperatures. Food Addit. Contam., 21 (4), 317–322.

Correia M., Barroso A., Barroso M.F., Soares D., Oliveira M.B.P.P., Delerue-Matos C., 2010. Contribution of different vegetable types to exogenous nitrate and nitrite exposure. Food Chem., 120, 960–966.

Gajda-Wyrębek J., Jarecka J., Kuźma K., Mirkowska M., 2009. Zawartość azotanów V w sałacie i szpinaku w Polsce w latach 2007–2008. Bromat. Chem. Toksykol., 42, (3), 519–524.

Huber S.C., Bachmann M., Huber J.L., 1996. Post-translational regulation of nitrate reductase activity: a role for Ca^{2+} and 14-3-3 proteins. Trends Plant Sci., 1(12), 432–438.

Lundberg J.O., Feelisch M., Bjorne H., Jansson E.A., Weitzberg E., 2006. Cardioprotective effects of vegetables: Is nitrate the answer? Nitric Oxide, 15, 359–362.

Majkowska-Gadomska J., Arcichowska K., Wierzbicka B., 2009. Nitrate content of the edible parts of vegetables and spice plants. Acta Sci. Pol., Hortorum Cultus, 8(3), 25–35.

Mensinga T.T., Speijers G.J.A., Meulenbelt J., 2003. Health implications of exposure to environmental nitrogenous compounds. Toxicol. Rev., 22, 41–51.

Michłojć Z., Szewczuk C., 2003a. Teoretyczne aspekty dolistnego dokarmiania roślin. Acta Agrophysica, 85, 9–17.

Michałojć Z., Szewczuk C., 2003b. Praktyczne aspekty dolistnego dokarmiania roślin. Acta Agrophysica, 85, 19–29.

Michłojć Z., Horodko K., 2006. Wpływ dokarmiania pozakorzeniowego wapniem na plonowanie i skład chemiczny papryki słodkiej. Acta Agrophysica, 7(3), 67–679.

Pannala A.S., Mani A.R., Spencer J.P.E., Skinner V., Bruckdorfer K.R., Moore K.P., Rice-Evans C.A., 2003**.**The effect of dietary nitrate on salivary, plasma and urinary nitrate metabolism in humans. Free Rad. Biol. Med., 34 (5), 576–584.

Pennington J.A.T., 1998. Dietary exposure models for nitrates and nitrites. Food Control, 9(6), 358–395.

PN-92/A-75112 (neq ISO 6635-1984) Fruits, vegetables and derived products. Determination of nitrites and nitrates content.

Prasad S., Chetty A.A., 2008. Nitrate-N determination in leafy vegetables: study of the effects of cooking and freezing. Food Chem., 106, 772–780.

Ruiz J.M., Rivero R.M., Garcia P.C., Baghour M., Romero L., 1999. Role of $CaCl_2$ in nitrate assimilation in leaves and roots of tobacco plants (*Nicotiana tabacum* L.). Plant Science 141, 107–115.

Santamaria P., 2006. Nitrate in vegetables: toxicity, content, intake and EC regulation. J. Sci. Food Agric. 86, 10–17.

Saure M.C., 1998. Causes of tipburn disorder in leaves of vegetables. Sci. Hort., 76, 131–147.

Steinmetz K.A., Potter J.D., 1991. Vegetables, fruit and cancer. I. Epodemiology. Cancer Causes Control 2, 325–357.

Tamme T., Reinik M., Roasto M., Juhkam K., Tenno T., Kiis A., 2006. Nitrates and nitrites in vegetables and vegetable-based products and their intakes by the Estonian population. Food Addit. Contamin., 23(4), 355–361.

Van Velzen A.G., Sips A.J.A.M., Schothorst R.C., Lambers A.C., Meulenbelt J., 2008. The oral bioavailability of nitrate from nitrate-rich vegetables in humans. Toxicol. Letters, 181, 177–181.

Walker R., 1990. Nitrates, nitrites and N-nitrosocompounds: a review of the occurrence in food and diet and the toxicological implications. Food Addit. Contam. 7, 717–768.

WPŁYW DOLISTNEGO TRAKTOWANIA $CaCl_2$ (PRZED ZBIOREM) NA AKUMULACJĘ AZOTANÓW I AZOTYNÓW W ŚWIEŻEJ I PRZECHOWYWANEJ SAŁACIE MASŁOWEJ

Streszczenie. Liście sałaty są bardzo bogatym źródłem witamin, mikro- i makroskładników oraz związków biologicznie aktywnych. Jednakże rośliny te zawierają również związki antyżywieniowe, takie jak azotany i azotyny, których poziom zależy od warunków uprawy i przechowywania. Celem badań było określenie wpływu dolistnego stosowania $CaCl_2$ przed zbiorem na akumulację azotanów i azotynów w całych liściach i blaszkach liściowych świeżej i przechowywanej sałaty. Materiał badawczy stanowiła sałata odmiany Omega, uprawiana w szklarni. Roztwór $CaCl_2$ zastosowano w stężeniach 0,1M i 0,2M na sałatę, 20 i 10 dni przed zbiorem. Po zbiorze, część roślin została bezpośrednio poddana analizie, natomiast pozostałe rośliny były przechowywane w 4°C przez 7 i 14 dni w ciemnych foliach polietylenowych. Większe stężenie azotanów i azotynów stwierdzono w świeżych całych liściach niż w blaszkach liściowych. Dolistne traktowanie roślin $CaCl_2$ przed zbiorem spowodowało spadek poziomu azotanów i wzrost poziomu azotynów w całych liściach roślin świeżych. Największe zmiany zaobserwowano po zastosowaniu stężenia 0,1M $CaCl_2$. Podczas przechowywania sałaty, w blaszkach liściowych roślin nietraktowanych $CaCl_2$ zaobserwowano większe stężenie azotanów i azotynów w porównaniu do roślin świeżych. Traktowanie sałaty $CaCl_2$ spowodowało istotny spadek zawartości azotynów w całych liściach roślin przechowywanych przez 7 dni, natomiast w blaszkach liściowych wyższe ilości azotynów akumulowały się w sałacie przechowywanej w warunkach chłodniczych podczas całego okresu eksperymentalnego.

Słowa kluczowe: *Lactuca sativa* L., dolistne stosowanie $CaCl_2$, NO_3^-, NO_2^-, przechowywanie w warunkach chłodniczych

ACKNOWLEDGEMENT

Authors are thankful to Prof. dr hab. Józef Nurzyński Director of the Department of Cultivation and Fertilisation of Horticultural Plants, University of Life Sciences in Lublin his support in greenhouse experiments.

Accepted for print – Zaakceptowano do druku: 30.06.2011