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Cultivar-specific variation in the content of nitrates (V) and (III) depending on potato tuber storage

Odmianowe zróżnicowanie zawartości azotanów (V) i (III) w zależności od przechowywania bulw ziemniaka

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Słowa kluczowe: azotany, użytkowanie, odmiana, przechowywanie, stabilność, ziemniak

Abstract
The order to monitor the chemical pollution of food, the dynamic development of ecology and specialisation in potato production as well as its large consumption caused the investigations about the influence of storage time and genetic conditions of potato on contents of nitrates (V) and (III) in tubers for different use purposes during 2009–2011.
In the present study, eight cultivars of potatoes with different use purposes and duration of vegetation time obtained from producer Norika Poland INC were used: 'Albatros', 'Gala', 'Karatop', 'Karlena', 'Kiebitz', 'Lambada', 'Molli' and 'Pirol'.
The tubers of cultivars used for processing such as starch production ('Albatros') as well as chips and crisps ('Karlena') were characterised by the highest content of nitrates (V) and (III). After 6 months of storage, a significant decrease of nitrates (V) and (III) contents was observed, which from the point of view of the consumer should be considered as the beneficial effect. Regardless of cultivar, the depletion of nitrates (V) was in the mean of 4.7% and of nitrates (III) was about 4.4%. Regardless of the use purposes, the intake of 300 g of investigated potato tubers after harvest as well as after storage time does not exceed the recommended daily allowance for nitrates (V) and (III), where after the storage time this amount is even declining.

Streszczenie
Nakaz stałego monitoringu chemicznego zanieczyszczenia żywności, dynamiczny rozwój ekologii i specjalizacji w produkcji ziemniaka oraz duże jego spożycie, spowodowało, że w latach 2009–2011 podjęto badania, których celem było określenie wpływu okresu przechowywania oraz uwarunkowań genetycznych ziemniaka na zawartość azotanów(V) i azotanów(III) w bulwach przeznaczonych na różne kierunki użytkowania.
W badaniach użyto 8 odmian ziemniaka pochodzących od producenta Norika Polska Sp. z o.o. o różnej przydatności i długości okresu wegetacji: 'Albatros', 'Gala', 'Karatop', 'Karlena', 'Kiebitz', 'Lambada', 'Molli', 'Pirol'.
Najwyższą zawartością azotanów(V) i (III) charakteryzowały się bulwy odmian przeznaczonych do przetwórstwa zarówno do krochmalu ('Albatros'), jak i na frytki i chipsy ('Karlena'). Po okresie 6 miesiącach przechowywania nastąpił istotny spadek zawartości azotanów(V) i (III), co z punktu widzenia konsumenta należy uznać za zjawisko korzystne. Niezależnie od odmiany spadek NO_3^- wynosił średnio 4,7% a NO_2^- – 4,4%. Niezależnie od kierunku użytkowania spożycie 300 gramów badanych ziemniaków po zbiorze, jak i po przechowywaniu nie przekracza dziennej dopuszczalnej normy dla azotanów(V) i (III) a po przechowywaniu spożycie ich spada.

1. INTRODUCTION

A wide direction of use makes potato the basis of the diet of the Polish consumer. A high vegetable consumption results in the problem of accumulation of harmful substances, including nitrates (V) and (III) in vegetables being especially essential [Ierna 2009, Rytel 2010, Zarzecka et al. 2011, Leszczyński 2012a and b, Kostiw, Jabłoński 2013]. The development of potato processing has made it necessary to change the growing and yield management structure for the benefit of the processing material [Poberężny 2011]. The market has been introduced with many new cultivars allocated to specific products (dried matter, canned foods, frozen foods, French fries, crisps, starch, stillage industry as well as direct consumption). Depending on the purposes, the detailed material requirements differ. For the production of French fries and crisps – the content of sugars in tubers – and for starch – the starch quality, while for direct consumption – the tuber size, the peel smoothness, flesh colour and the susceptibility to darkening – are essential [Poberężny 2011, Leszczyński 2012b, Wszelaczyńska et al. 2007, 2013]. Due to long-term potato consumption after harvest, it must be stored even up to 9 months [Krzysztofik, Skonieczny 2010, Zgórska, Sowa-Niedziałkowska 2005, Wszelaczyńska et al. 2007, 2013].
The order of a permanent chemical contamination monitoring, a dynamic development of ecology and specialisation in potato production as well as its high consumption have resulted in the launch of the present research to verify the content of nitrates (V) and (III) after harvest and after storage in the tubers of the cultivars allocated to different uses.

2. MATERIALS AND METHODS

The research (2009–2011) involved the use of eight potato cultivars received from the producer of seed-potatoes NORIKA POLSKA S.A. for a direct consumption ('Gala', 'Karatop', 'Lambada' and 'Molli'), for food processing, i.e. for the production of French fries and crisps ('Karlena', 'Kiebitz', 'Pirol') as well as for starch production ('Albatros').

Mineral fertilisers in the form of urea (46%), nitro-chalk (27%) and polifoska 4 (4% N – 12% P_2O_5 – 32% K_2O) were applied in Spring before planting, at the following amounts: nitrogen – 100 kg N•ha^{-1}, phosphorus – 110 kg P_2O_5•ha^{-1}, potassium – 150 kg K_2O•ha^{-1}. Experimental fields differed inconsiderably. Potatoes were grown on FYM 25 t•ha^{-1}; cereal crops served as the forecrops. Potato tubers (10-kg samples) were stored for 6 months in the chambers with controlled atmosphere. In the chambers, there was maintained a constant temperature which depended on the direction of use and relative air humidity of 95%. For direct consumption and for the production of starch, the temperature of storage is +4°C, while for the production of French fries and crisps +8°C.

The scope of the analytical research covered determining the content of nitrates (V) with the ion-selective method using the multifunctional apparatus CX-721 provided by Elmetron [Baker, Thompson 1992], while the content of ions NO_2^- was defined after their oxidation to NO_3^-, in the earlier prepared extract sample according to the abovementioned method.

The research has been an attempt at providing a model definition of the daily nitrate uptake (V) and (III) with the consumption of 300 g of the tubers studied. The research results were exposed to statistical calculations, applying the method of the analysis of variance for the two-factor experiments, using the Tukey test to evaluate the differences. Besides, the coefficients of variation and linear correlation were calculated.

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3. RESULTS AND DISCUSSION

The content of nitrates (V) in potato tubers of the cultivars studied ranged from 118.4 to 176.3 mg•kg^{-1} of fresh weight (Table 1), which complies with the results reported by Leszczyński [2012a] who claims that the content of nitrates (V) in potatoes ranges from 110 to 180 mg•kg^{-1} of fresh weight. Marks [2009] report on the content of nitrates (V) being much lower 77.0–102.0 mg•kg^{-1} of fresh weight, and according to Murawa et al. [2008], the content of nitrates (V) ranged from 167.1 to 259.6 mg•kg^{-1} of fresh weight. Whereas Lachman and Hamouz [2005], Hamouz et al. [2005] as well as Zgórska and Sowa-Niedziałkowska [2005] noted different values in the range of 70.2–199.2 as well as 71.0–270.0 mg•kg^{-1} of fresh weight. Murawa et al. [2008] defined the potato as a vegetable crop posing a high threat to the consumer, since among the tubers available on sale, it recorded and exceeded the admissible amount of the content of nitrates (V) in the first research year in 30% of the samples and in the second year – even in 72% of the samples. Tamme et al. [2006], on the other hand, investigating potatoes from Estonian market, considered it as a vegetable with an average tendency to the accumulation of nitrates (V) despite exceeding the admissible amount even by 160 mg•kg^{-1} of fresh weight.

The cultivars differed significantly in the content of nitrates (V) (Table 1). According to Jarych-Szyszka [2006], Tamme et al. [2006], Ierne [2009] as well as Rytel [2010], the content of nitrates (V) in tubers is affected by the genotype. However, according to Hamouz et al. [2005], Lachman and Hamouz [2005], Rogozińska et al. [2005] as well as Łozowicka [2009], the significant differences in the content of nitrates (V) arise from different growing conditions for different directions of use. Potato allocated to food industry most often come from traditional plantations where, despite high mineral fertilisation rates, an intensive protection is also used. It can increase the content of nitrates (V) even above the amount considered to be safe [Murawa 2008, Ierna 2009, Rytel 2010], which is confirmed by the results of the present research since the highest content of nitrates (V) was reported for the tubers of the cultivars allocated to processing, both for starch and French fries and crisps (Table 1). The highest content of nitrates (V) was recorded for the 'Albatros' tubers (176.3 mg•kg^{-1} of fresh weight –

Table 1. Content of nitrates (V) and (III) in [mg•kg^{-1} of fresh weight] as well as the coefficients of variation CV [%] depending on the genetic conditions and the research date

CULTIVAR (A)	Nitrates (V)			Nitrates (III)			CV			
	Research date (B)						NO_3^-		NO_2^-	
	After harvest*	After storage*	Mean	After harvest*	After storage*	Mean	After harvest	After storage	After harvest	After storage
Albatros*	176.3	167.8	172.0	1.33	1.29	1.31	4.39	1.52	4.54	5.55
Gala**	118.4	107.6	113.0	0.65	0.62	0.64	4.88[2)]	3.89[2)]	1.97	2.53
Karatop**	134.1	126.6	130.3	0.68	0.64	0.66	2.73	1.33	0.86[1)]	3.69
Karlena***	155.8	153.1	154.5	1.13	1.04	1.09	2.91	1.54	4.00	1.17[1)]
Kiebitz***	131.7	124.4	128.0	0.73	0.72	0.73	0.79[1)]	0.98[1)]	12.75[2)]	1.47
Lambada**	138.7	131.4	135.0	0.90	0.88	0.89	0.91	2.16	10.33	8.14[2)]
Molli**	126.4	124.4	125.4	0.75	0.74	0.75	3.38	2.94	4.77	1.75
Pirol**	150.8	144.5	147.6	1.04	0.95	0.99	1.60	2.62	0.96	1.87
Mean	141.5	135.0	138.2	0.90	0.86	0.88	2.70	2.12	5.02	3.27
LSD α=0.05	A – 7.17 A×B – n.s.	B – 3.14 B×A – n.s.		A – 0.09 A×B – n.s.	B – 0.03 B×A – n.s.		[1)] - lowest variation, [2)] - highest variation			

*For starch production.
**For the direct consumption.
***For food processing.

for starch production) and 'Karlena' (155.8 mg•kg^{-1} of fresh weight – for the production of French fries and crisps), which coincides with the results reported by others [Prośby-Białczyk 2004 and Rutkowska 2005]. Rogozińska et al. [2005] and Jarych-Szyszka [2006] claim differently; the cultivars allocated to processing accumulated nitrates (V) less considerably than those allocated to direct consumption. Hamouz et al. [2005] as well as Lachman and Hamouz [2005], on the other hand, observed a tendency to a higher content of nitrates (V) in the tubers of the cultivars grown treated with high rates of mineral fertilisation (153.9 mg•kg^{-1} of fresh weight), as compared with the cultivation with a limited fertilisation and protection (136.9 mg•kg^{-1} of fresh weight). This dependence concerned all the cultivars they investigated ('Impala', 'Karin', 'Agria', 'Nimfa', 'Korela', 'Rosella', 'Sante' and 'Orwella') irrespective of the direction of their use. Similar results were noted by Rogozińska et al. [2005], Zarzyńska and Goliszewski [2005], Pussemier et al. [2006], Janowiak et al. [2009] and Kostiw and Jabłoński [2013].

In the present research, the lowest content of nitrates (V) was found for the cultivars allocated to direct consumption (Table 1). In that group, the cultivars differed significantly from one another in the content of nitrates (V). The lowest content was reported for 'Gala' – 118.4 mg•kg^{-1} of fresh weight and the highest for 'Lambada' – 138.7 mg•kg^{-1} of fresh weight. It complies with the results by Mozolewski and Smoczyński [2004] as well as Jarych Szyszka [2006] who determined the content of nitrates (V), respectively, at the level of 80 mg•kg^{-1} of fresh weight for 'Bard' and 'Lord' as well as 130.1 mg•kg^{-1} of fresh weight for 'Ibis' – 140.3 mg•kg^{-1} of fresh weight. Rutkowska [2005] and Jarych-Szyszka [2006] did not find significant differences in the accumulation of nitrates (V) across the cultivars of potato allocated to direct consumption ('Bard', 'Lord', 'Bryza', 'Sokół' and 'Irys'). Zarzyńska and Wroniak [2007] observed a disturbing phenomenon for the accumulation of a high amount of nitrates (V) in the tubers of the cultivars allocated to direct consumption even above 600 mg•kg^{-1} of fresh weight; however, it applied only to the early and very early cultivars. Mid-early and later cultivars, similarly as in the present research and the research reported by Łozowicka [2009], did not accumulate high amounts of NO_3^-. Nitrates (V) show little toxicity and do not pose a direct threat to human health. Some of them can be, however, reduced by microflora of the alimentary canal to nitrates (III), nitrogen oxides and even ammonia, which are toxic compounds [Tamme et al. 2006, Murawa et al. 2008, Łozowicka 2009, Marks 2009, Leszczyński 2012b]. In the present research, irrespective of the cultivar, the mean content of nitrates (III) after harvest as well as after storage was 0.90 and 0.74 mg•kg^{-1} of fresh weight, respectively (Table 1). Murawa et al. [2008], investigating 24 potato samples over 2 years , obtained from accidental sales outlets recorded the mean content of nitrates (III) to be higher than in the present research, namely on average 1.70 mg•kg^{-1} of fresh weight. One shall note, however, that the highest content was as much as 2.60 mg•kg^{-1} of fresh weight. Similar results were reported by Mozolewski and Smoczyński [2004]: from 1.05 to 1.30 mg•kg^{-1} of fresh weight. Leszczyński [2012b] reports on the content of nitrates (III) in tubers from 0 to 3.00 mg•kg^{-1} of fresh weight. Most nitrates (III) after harvest, similarly as nitrates (V), were obtained in the cultivar for the starch production, followed by processing for French fries and crisps and the lowest content – for direct consumption (Table 1). Such dependence is confirmed by the calculated positive coefficients of correlation between nitrates (V) and (III) after harvest ($r = 0.745$; $P_{0.01}$) as well as after storage ($r = 0.452$; $P_{0.05}$).

After 6 months of storage, there was a significant decrease in the content of nitrates (V) and (III), which, from the consumer's perspective, must be considered favourable (Fig. 1). Irrespective of the cultivar, the decrease in the content of nitrates (V) was on average 4.7% and nitrates (III) 4.4%, which complies with the results reported by Wichrowska [2007] and Poberežny et al. [2012], where the content of nitrates (V) after 6 months of storage decreased by 10.6% and 37.5%, respectively. The opposite

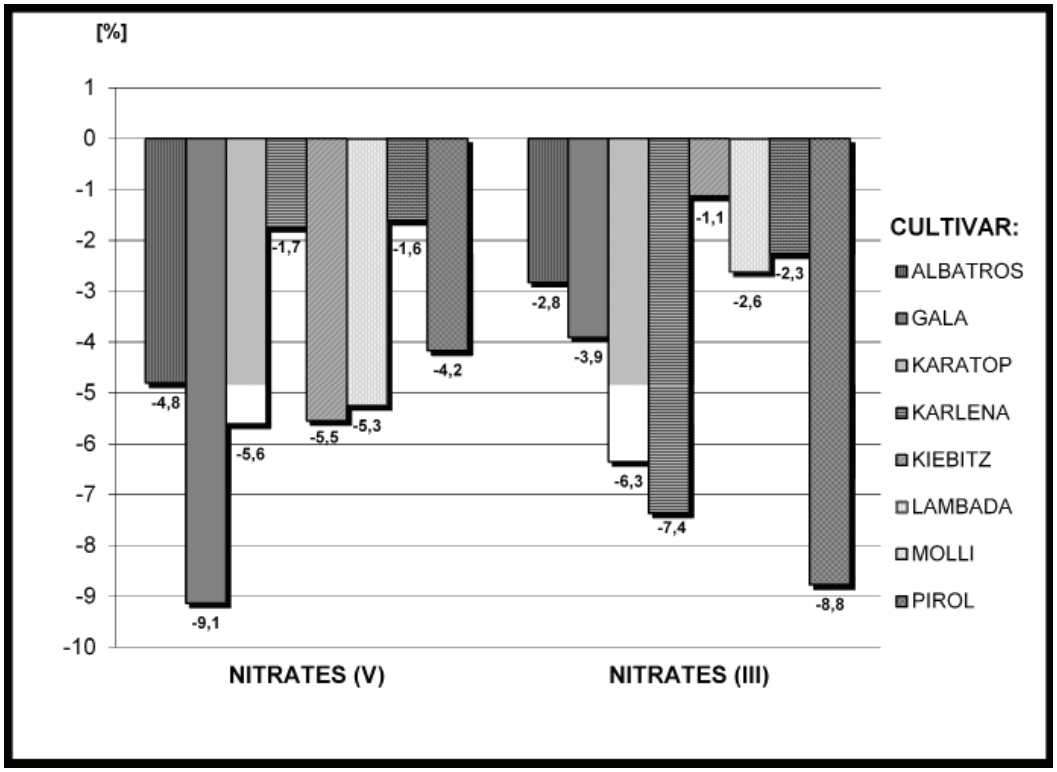

Fig. 1. Percentage losses of the content of nitrates (V) and (III) in potato tubers depending on the cultivar and the storage period

Table 2. Daily consumption [mg] with the consumption of 300 g* of potato tubers

CULTIVAR	NITRATES (V)		NITRATES (III)	
	After harvest	After storage	After harvest	After storage
ALBATROS	52.9	50.3	0.40	0.39
GALA	35.5	32.3	0.19	0.19
KARATOP	40.2	38.0	0.20	0.19
KARLENA	46.8	45.9	0.34	0.31
KIEBITZ	39.5	37.3	0.22	0.22
LAMBADA	41.6	39.4	0.27	0.26
MOLLI	37.9	37.3	0.23	0.22
PIROL	45.2	43.3	0.31	0.28
Mean	**42.5**	**40.5**	**0.27**	**0.26**

* mean consumption of potato tubers is 109 kg year^{-1} per person in Poland

result was reported by Gajewska et al. [2009] and Ciećko et al. [2010], which could have been due to the storage conditions. In the present research, the tubers were stored in controlled conditions adequately selected to the direction of use. Gajewska et al. [2009], on the other hand, made an accidental purchase at the market not knowing the storage conditions. Interestingly, according to many authors, inadequate conditions of storage (increased temperature and no oxygen access) results in an increased content of nitrates (V) in vegetable crops [Zgórska and Sowa-Niedziałkowska 2005, Gajewska et al. 2009, Ierna 2009, Ciećko et al. 2010]. Sądej et al. [2007] claim that after storage in tubers, there was an increase in the concentration of NO_3^- and it was 13.5 mg•kg^{-1} of fresh weight, in relation to the content noted after harvest. Similar results were recorded by Cienko et al. [2010]. However, in the research reported by Marks [2009], the effect of storage on the content of nitrates (V) appeared non-significant.

After storage, the greatest decrease in the content of nitrates (V) was noted in the cultivars allocated to direct consumption – 5.4%, followed by starch – 4.8% and to production of French fries and crisps – 3.8% (Fig. 1), while nitrates (III) dropped on average most in French fries-crisps – 5.8%, table potatoes – 3.8% and starch – 2.8%. The greatest and the lowest decrease in nitrates (V) was recorded for table cultivars: 'Gala' – 9.1% and 'Molli' - 1.6%,while in nitrates (III) of the cultivars for French fries and crisps: 'Pirol' – 8.8% and 'Kiebitz' – 1.1%. The mean coefficient of variation CV (Table 1) for nitrates (V) after harvest accounted for 2.70% and for nitrates (III) – 5.02%, whereas after storage, 2.12% and 3.27%, respectively. It points to a greater dependence of the nutrients on the genotype after harvest than after storage. The calculated coefficients of variation for cultivars point that for both features, the 'Gala' potatoes showed the highest variation and 'Kiebitz' – the lowest both after harvest and after storage. Recording low coefficients of variation can mean maintaining the agrotechnical and storage regime determined for respective directions of use.

The Joint FAO/WHO Expert Committee on Food [2002] determined the value of daily consumption from all the sources for nitrates (V) from 0 to 3.7 and for nitrates (III) from 0 to 0.07 mg•kg^{-1} of the body weight. The contents show that the ADI (Acceptable Daily Intake by the man of 60 kg in weight cannot exceed 222 mg of nitrates (V) and 4.2 mg nitrites (III) [Burt et al. 1993]. Irrespective of the direction of use, the consumption of 300 g of potato after harvest and after storage does not exceed the daily admissible norm (Table 2) for nitrates (V) and (III) and after storage, their consumption decreases and it complies with the results noted by Rogozińska et al. [2005].

The lowest number of nitrates (V) and (III) is supplied to the body through the consumption of potato allocated to direct consumption and most – constituting the material for processing. In that matter, Rogozińska et al. [2005] reported opposite results.

4. CONCLUSIONS

Of all the groups of use, most nitrates (V) and (III) were recorded in potatoes allocated to starch production and least for direct consumption. Of the groups of cultivars for the production of French fries and crisps, the least amount of NO_3^- and NO_2^- was accumulated by 'Kiebitz', and, in terms of table potatoes, 'Gala'. Irrespective of the purpose, the cultivars meet the requirements specified concerning with the content of nitrates (V) and (III). Irrespective of the direction of use, the potatoes do not exceed the daily and admissible norm for intake of nitrates (V) and (III) both after harvest and after storage. Storage decreases the content of both nitrates (V) and (III). In the potato production, one shall maintain the agrotechnical regime and in the storage room compliant with their directions of use.

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REFERENCES

BAKER W. H., THOMPSON T. L. 1992. Determination of nitrate nitrogen in plant samples by selective ion electrode. Plant Anal. Ref. Proc. for S. US (SCSB # 368); 23-26.

BURT T. P., HEATHWAITE A. L., TRUDGILL S.T. 1993. Nitrate: Process, pattern and management. Chichester, England, Wiley, 10-28.

CIEĆKO Z., ŻOŁNOWSKI A., MIERZEJEWSKA A. 2010. Effect of Foliar Nitrogen and Magnesium Fertilization on the Total, Protein Nitrogen and Nitrates(V) Content in Potato Tubers. Ecological Chemistry and Engineering,. 17(6): 593-600.

GAJEWSKA A., CZAJKOWSKA A., BARTODZIEJSKA B. 2009. The content of nitrates (III) and (V) in selected vegetables on

detail sale in Lodz region. Ochrona Środowiska i Zasobów Naturalnych 40: 388-395.

HAMOUZ K., LACHMAN J., DWORAK P., PIEC V. 2005. The effect of ecological growing on the potatoes field and quality. Plant Soil Environment 51(9): 397-402.

IERNA A. 2009. Influence of harvest date on nitrate contents of three potato varieties for off-season production. J. Food Comp. Anal. 22: 551-555.

JANOWIAK J., MURAWSKA B., SPYCHAJ-FABISIAK E., WSZLACZYŃSKA E., PIŃSKA M. 2009. Effect of many-year natural and mineral fertilization on Fielding and the content of nitrates (V) in potato tubers. Journal Central European Agriculture Vol. 10(1): 109-114.

JARYCH-SZYSZKA M. 2006. Wpływ nawożenia azotowego na zawartość azotanów (V) w bulwach ziemniaka. Żywność. Nauka. Technologia. Jakość 2(47): 76-84.

KOSTIW M., JABŁOŃSKI K. 2013. Wpływ nawożenia azotem na plon i jakość bulw odmian jadalnych ziemniaka uprawianych na glebie średniej. Biul. Instyt. Hodowl. i Aklimat. Roślin, 267: 397-106.

KRZYSZTOFIK B., SKONIECZNY P. 2010. Wpływ okresu przechowywania na zmiany właściwości fizycznych bulw ziemniaka. Inżynieria Rolnicza 4(122): 135-141.

LESZCZYŃSKI W. 2012(a). Znaczenie ziemniaka jako produktu żywnościowego oraz w przetwórstwie przemysłowym. Ziemniak Polski., 1: 38-43

LESZCZYŃSKI W. 2012(b). Żywieniowa wartość ziemniaka i przetworów ziemniaczanych. Biul. Inst. Ziemn., 266: 5-20.

LACHMAN J., HAMOUZ K., 2005. The effect of selected factors on the content of protein and nitrates in potato tubers. Plant, Soil and Environment 51(10): 431-438.

ŁOZOWICKA B. 2009. Chemical contaminants in plant ford. Progress in Plant Protection. Postępy w Ochronie Roślin, 49(4) : 2071-2080.

MARKS N. 2009. Zawartość azotanów, azotynów i metali ciężkich w bulwach ziemniaka w zależności od długości okresu przechowywania. Inżynieria Rolnicza 1(11): 183-187.

MOZOLEWSKI W., SMOCZYŃSKI S. 2004. Effect of culinary processes on the content of nitrate in potatoe. Pakistan Journal of Nutrition 3 (6): 357-361.

MURAWA D, BANASZKIEWICZ B., MAJEWSKA E., BŁASZCZUK B., SULIMA J. 2008. Zawartość azotanów (III) i (V) w wybranych gatunkach warzyw i ziemniakach dostępnych w handlu w Olsztynie w latach 2003-2004. Bromat. Chem. Toksykol. XLI(1): 67-71.

POBEREŻNY J. 2011. Effect of physicochemical properties of starch on the tendency of potato tuber flesh to darkening and the processed product quality. Starch – Stärke, 63(2): 106–116.

POBEREŻNY J., DUDEK S., WSZELACZYŃSKA E., KUŚMIEREK-TOMASZEWSKA R., ŻARSKI J., KEUTGEN A.J. 2012. Zawartość azotanów (V) w bulwach ziemniaka jadalnego w zależności od nawadniania, sposobu nawożenia azotem oraz przechowywania. Journal of Elementology Suplement 17(3): 54-55.

PROŚBA-BIAŁCZYK U., NOWAK L., MAKOWSKI K. 2004. Wpływ nawadniania i nawożenia azotem na produkcyjność dwóch odmian ziemniaka. Zesz. Prób. Post. Nauk Rol. 500: 313-323.

PUSSEMIER L., LARONDELLE Y., van PETEGHEM C., HUYGHEBAERTA. 2006. Chemical safety of conventionally and organically produced foodstuffs a tentative comparison under Belgian conditions. Food Contr. 17: 14-21.

ROGOZIŃSKA I., POBEREŻNY J., DELGADO E., PAWELZIK E. 2005. The effect of different factors on the content of nitrate in some potato varieties. Potato Res., 48:167-180.

RUTKOWSKA G. 2005. Ziemniaki i marchew z gospodarstw ekologicznych i konwencjonalnych. Przemysł Fermentacyjny i Owocowo-Warzywny 5: 20-21.

RYTEL E. 2010. Wybrane substancje odżywcze i antyżywieniowe ziemniaka i zmiany ich zawartości podczas przetwarzania na produkty spożywcze. Zesz. Probl. Post. Nauk Rol., 557, 43-61.

SĄDEJ W., ŻOŁNOWSKI A. C., PRZEKWAS K. 2007. Effects of various fertilization systems on the dynamics of nitrate(V) concentrations in potato tubers after harvest and during storage. Pol. J of Nat. Sc., Vol.22(1): 15-22

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. Contam. 23: 355–361.

WICHROWSKA D. 2007. The content of nitrate(V) in potato tubers storage in temperature 4oC. Pol. Jour. of Nat. Sci., 4:121-127.

WSZELACZYŃSKA E., JANOWIAK J., SPYCHAJ-FABISIAK E., PIŃSKA M. 2007. Wpływ nawożenia na wybrane cechy jakościowe bulw ziemniaka odmiany Bila. Acta Sci. Pol., Agricultura 6(4): 91-96.

WSZELACZYŃSKA E., POBEREŻNY J., ŻARY-SIKORSKA E., MAREČEK J. 2013. Wpływ miejsca uprawy i przechowywania bulw na wybrane cechy kulinarne trzech odmian ziemniaka. Inż. i Aparat. Chem., 2: 68-70.

ZARZECKA K., GUGAŁA M., MILEWSKA A. 2011. Oddziaływanie Użyźniacza Glebowego UGmax na plonowanie ziemniaka i zdrowotność roślin. Postępy w Ochronie Roślin 51(1): 153-157.

ZARZYŃSKA K., GOLISZEWSKI W. 2005. Jakość plonu i problemy ekologicznej uprawy ziemniaków na różnych typach gleb. Ziemniak Polski 1: 25-27.

ZARZYŃSKA K., WRONIAK J. 2007. Różnice w jakości plonu bulw ziemniaków uprawianych w systemie ekologicznym w zależności od niektórych czynników agrotechnicznych. Journal of Res. and Appl. in Agric. Eng., 52(4): 108-113.

ZIARATI P., ARBABI-BIDGOLI S. 2014. Investigation of cooking method on nitrate and nitrite contents in crops and vegetables and assess the associated health risk. Intern. Journ. of Plant, Anim. and Envir. Sc., 4(2): 46-52.

ZGÓRSKA K., SOWA-NIEDZIAŁKOWSKA G. 2005. Wpływ czynnika termicznego i odmiany na zmiany jakościowe zachodzące w bulwach ziemniaka w czasie ich długotrwałego przechowywania. Pam. Puł., 138: 327-336.