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Influence of harvest date on glycoalkaloid contents of three potato varieties

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Abstract

The influence of potato variety, time of tuber harvesting and peeling operation was investigated on the α-solanine and α-chaconine contents of potato tubers of three Polish varieties: *Aster*—very early, *Mila*—middle-early and *Bryza*—middle-late. Samples of tubers were harvested in three different periods of time. Unpeeled and peeled tubers were subjected to freeze-drying. In the powders obtained, the contents of α-solanine and α-chaconine glycoalkaloids were determined by HLPC. Investigated varieties differed in respect of both contents of glycoalkaloids and the ratio of α-solanine to α-chaconine. The tubers of the early variety *Aster*, harvested in the I period of time, contained the highest amount of glycoalkaloids, while the tubers of the middle-late variety *Bryza*, harvested in the II and III periods, contained the lowest amount of glycoalkaloids. The peeling of tubers caused a decrease of α-solanine and α-chaconine contents in the investigated potatoes and this obscured the differences between varieties. The contents of these compounds in peeled tubers of studied potato varieties remained at a similar low level, regardless of the glycoalkaloid contents in tubers before peeling.

Keywords: Glycoalkaloids; Potato; Harvest date; Peeling

1. Introduction

Potato tubers of different varieties show different contents of glycoalkaloids, compounds occurring in few species of plants, mainly *solanaceae*. Glycoalkaloids found in the potato are mainly steroid glycosides, derivatives of solanidine, i.e. an aglucone containing nitrogen (Lisińska & Leszczyński, 1989; Maga, 1980; Wilska-Jeszka, 1994). Steroid glycoalkaloids, in concentrations over 20 mg/100 g of potato, are toxic and may cause development defects of man and animals (Leszczyński, 1994; Sinden, Sanford, & Webb, 1984). Predominant compounds are α-solanine and α-chaconine, while the ratio of concentration α-solanine to α-chaconine differs, depending on the anatomical part of the potato plant or its variety and ranges from 1:2 to 1:7 (Bejarano, Mignolet, Devaux, Carrasco, & Larondelle, 2000; McCay, McCay, & Smith, 1987; Spijers, 1998; Wunsch & Munzert, 1994). Most of them are found in flowers, foliage and sprouts. Total contents of glycoalkaloids (TGA) in potato tubers of different varieties depends on the maturity of the tubers, their size and extent of damage as well as on climate, cultivation and storage conditions (Gregory, 1984; Kuc, 1984; Love, Herman, Thompson-Johns, & Baker, 1994; Maga, 1980; Rogozińska & Wojdyła, 1999). In mature tubers it ranges on average from 3 to l0 mg/100 g of the potato, without being a danger to human health (Gregory, 1984; Kuc, 1984; Lisińska & Leszczyński 1989; McCay et al., 1987; Sinden et al., 1984; Spijers, 1998; Wunsch & Munzert, 1994). The highest glycoalkaloid concentration is in the outer layer of the tuber, especially next to eyes and injuries. The potato peel, 2–3% weight of the tuber, contains 30–60 mg TGA. That is why peeling of potatoes usually decreases glycoalkaloid contents to a safe level, especially in the case of small tubers which contain great amount of these compounds. According to the results of investigations carried out by several authors (Kuc, 1984; Lisińska & Leszczyński, 1989; Sinden et al., 1984), the variety of potato synthesising great amounts of TGA, will show this tendency, regardless of growth environment. It will also accumulate more of these

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compounds as a result of stress, in comparison with varieties of lower susceptibility to their formation.

During the growth and maturation of potato tubers a decrease in glycoalkaloid contents occurs. The decrease is considerable as early as 52 days after vegetation begins. (Papathanasiou et al., 1998; Sinden et al., 1984). In 100 g immature tubers, 2.8–3.8 mg α-solanine and 6.6–8.4 mg α-chaconine were found and, in mature ones, 0.4–1.0 mg α-solanine and 1.1–3.0 mg α-chaconine (Lisińska & Leszczyński, 1989). The period of 118 days of vegetation can be considered as long enough for the tubers of most varieties to reach maturity. The changes of glycoalkaloid contents in tubers that occur during further days of vegetation can be caused by factors other than the process of maturing (Sinden et al., 1984).

There is still an increasing demand for tubers of varieties with shorter vegetation periods, maturing during the first days of summer and consumed as a cooked potato. This prompts a need to determine the amounts of glycoalkaloids in potato tubers of varieties with different vegetation periods, harvested at different stages of their maturity, as well as to estimate the risk of their consumption.

The purpose of this investigation was to define the influence of a potato variety, harvest date and the peeling process on the contents of α-solanine and α-chaconine in the tuber.

2. Materials and methods

2.1. Raw material

The materials for investigation were samples of tubers of three Polish potato varieties: *Aster*—very early, *Mila*—middle-early and *Bryza*—middle-late, cultivated in the Agricultural Experimental Institute in Pawłowice in the years 1998–2000.

2.2. Method of collecting samples

For the purpose of the investigation, tuber samples were collected from the fields, at random, in amounts of about 20 kg. Potatoes of *Aster* variety were collected in the first period of time—after 60 days of vegetation, in the second period—after 80 days and in the third period—when the tubers were fully mature (after ca. 100 days of vegetation). Potatoes of *Mila* variety were collected in the first period—after 80 days of vegetation, in the second period—after 100 days and in the third period—in full maturity of the tubers (after ca. 120 days of vegetation). Potatoes of *Bryza* variety were collected in the first period—after 100 days of vegetation, in the second—after 120 days and in the third period—in full maturity of the tubers (after ca. 140 days of vegetation).

2.3. Potato sample preparation for the analysis

Unpeeled and peeled tubers were cut in 1-cm-thick slices and freeze-dried. The dry material obtained, after being ground in an electric grinder, became the material used for defining the contents of α-solanine and α-chaconine.

2.4. Apparatus

A high-pressure liquid chromatograph HPLC (Pro Star) was used, made by the Varian company (Walnut Creek, CA, USA), equipped with UV detector - 310 type, analytical column Mikrosorb NH2 (25×46 cm LD.) (Rainin Instrument, Woburn, MA, USA) and a computer system monitoring the chromatograph (Varian Chromatography Systems).

2.5. Conditions of the glycoalkaloid separation

As an eluent, a mixture of tetrahydrofuran, acetonitrile, water 50:30:20 + /KH_2P0_4 (1.70 g) was used. The process was carried out at a temperature of 35 °C, with the speed of flow of 2 cm^3/min and pressure of 112 atm, applying the light wavelength of 208 nm.

2.6. Sample preparation for the chromatograph analysis

The freeze-dried material (1 g) was homogenised with 4 cm^3 of water and 30 cm^3 of methanol for 2 min, followed by filtration. The filtrate was brought to a final volume of 50 cm^3 with methanol. A 5 cm^3 aliquot of the extract was cleaned up on the SPE column. Glycoalkaloids were rinsed with methanol and evaporated to dryness in vacuo at a temperature of 50 °C. The residue formed was dissolved in 1 cm^3 of THF:ACN:H_2O 50:30:20. Before application onto the column, the sample was cleaned up by using filters of 0.45 μm. The volume of the injection was 10 μl.

Standard solutions (1 mg/cm^3) were prepared by dissolving l0mg of α-solanine and α-chaconine (Sigma) in l0 cm^3 of methanol; 10 μl, containing from 1 to 50 μg/cm^3 for both α-solanine and α-chaconine, were injected.

2.7. Analytical methods

The dry matter of fresh potato tubers and freeze-dried material was determined by the reduced weight after drying at 102 °C and until constant weight was achieved (AACC, 1968). The quantities of α-solanine and α-chaconine in potato were determined by the method of Saito, Horie, Hoshino, and Nose (1990). All analyses were done twice.

2.8. Statistical analysis

The results obtained in the experiment were subjected to statistical calculations according to the Statgraphics

programme. One-way analysis of variance was used and the Tukey range test for the determination the significance of the influence of potato variety, the time of harvesting and peeling process on the contents of α-solanine and α-chaconine in potato tubers.

3. Results and discussion

Investigated potato varieties differed in respect of glycoalkaloids contents, in general, as well as in respect of the ratio of α-solanine to α-chaconine contained in them. Very early *Aster* variety and middle-early *Mila* variety made one homogeneous group, containing more glycoalkaloids in tubers, namely: 13.7 mg/100 g of fresh mass and 9.33 mg/100 g, in comparison to middle-late *Bryza* variety: 6.34 mg/100 g (Fig. 1).

Investigated tubers contained from 2.4 to 4 times more α-chaconine than α-solanine, both unpeeled and peeled. The greatest differences in contents of the compounds mentioned above were observed in the samples of *Aster* and *Bryza* tubers (Table 1). According to the investigations of other authors (Bajerano et al., 2000; Wünsch & Munzert, 1994), the ratio of α-chaconine to α-solanine is between 2:1 and 7:1.

Investigations carried out by many authors (Gregory, 1984; Love et al., 1994; Papathanasiou, Mitchell, & Harvey, 1998; Sinden et al., 1984; Wunsch & Munzert, 1994) prove that the contents of glycoalkaloids in potato of varieties *Solanum*, (containing mainly α-solanine and α-chaconine) can change both within the range of varieties and between them. They also prove that existing differences result from a variety of characteristics, including the length of vegetation period, as well as diverse cultivation, environmental and storage factors. For most cultivated varieties, the amounts of glycoalkaloids do not exceed 20 mg/100 g of fresh tuber mass, remaining in the range of 2–13 mg/100 g of fresh mass.

The contents of α-solanine and α-chaconine in unpeeled tubers of investigated potato varieties, harvested in three

Table 1
The contents of α-chaconine and α-solanine (mg/100 g) in the fresh matter of unpeeled and peeled tubers of three potato varieties, harvested in the three periods of time (the mean values of 3 years)[a]

Variety	Period	α –Chaconine		α-Solanine	
		Unpeeled(a)	Peeled(b)	Unpeeled(a)	Peeled(b)
Aster(a)	I(b)	13.75	3.01	3.69	1.47
	II(ab)	9.56	4.35	3.99	2.11
	III(a)	7.08	2.44	3.11	1.26
Mila(a)	I(b)	7.64	5.18	3.32	2.21
	II(ab)	6.47	4.44	2.67	1.78
	III(a)	5.80	3.03	2.09	1.10
Bryza(b)	I(b)	5.58	3.50	2.52	1.09
	II(ab)	4.07	3.11	1.56	0.84
	III(a)	3.87	2.24	1.44	0.85

[a] (a,b)Homogeneous groups, determined by Tukey test.

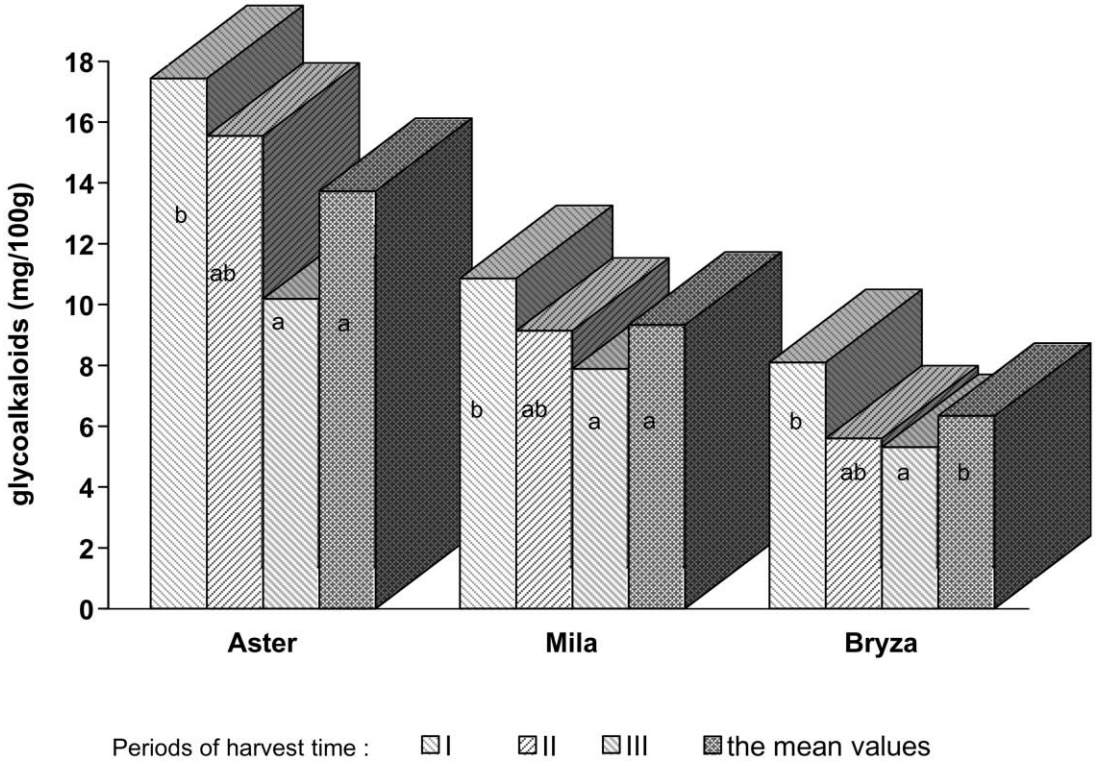

Fig. 1. The contents of total glycoalkaloids in tubers of three potato varieties, harvested in three periods of time (the mean values of 3 years).

periods of time ranged, on average, between 3.87 and 13.8 mg/100 g of fresh tuber mass (Table 1) for α-chaconine and between 1.44 and 3.99 mg/100 g for α-solanine. The contents of these glycoalkaloids in peeled tubers ranged from 2.24 to 5.18 mg/100 g of fresh tuber mass for α-chaconine and from 0.84 to 2.21 mg/100 g for α-solanine. The total amounts of glycoalkaloids (Fig. 1) did not exceed values regarded as dangerous for human health, i.e. 20 mg/100 g of fresh tuber mass (Kuc, 1984; Leszczyński, 1984; Spijers, 1998). The highest contents of these compounds were found in the potato of very early *Aster* variety, harvested in the first period—17.4 mg/100 g. However, most was lost during the peeling process as reported by other authors (Bushway, Bureau, & McGann, 1983). The amounts of α-chaconine (3.01 mg) and α-solanine (1.47 mg) remaining in tubers of the *Aster* variety after peeling were at similar low levels also in the case of the other samples, regardless of the potato variety or the time of harvest. The glycoalkaloids in peeled tubers were within relatively narrow ranges of concentrations, regardless of their contents in unpeeled tubers. The differences between the varieties were obscured. According to Haddadin, Humeid, Quaroot, and Robinson (2001), the peeling process may turn out to be in sufficient, especially for the tubers containing considerable amounts of glycoalkaloids, exceeding the level safe for human health.

The data obtained during the experiment (Table 1) show that the contents of glycoalkaloids in unpeeled and peeled tubers of the investigated varieties decreased with delaying of the harvest date; maximum decreases were: 42% for *Aster* variety, 27% for *Mila* variety and 34% for *Bryza* variety. Significant differences in contents of α-chaconine and α-solanine were observed in the case of samples harvested in the first and third periods. Distinct differences in glycoalkaloid contents between tubers harvested in these periods could be due to the smaller sizes of tubers harvested before they reached maturity. They usually contain more glycoalkaloids, which is caused by irregular deposition of the compounds in tubers. Smaller tubers, with relatively higher numbers of outer layers, are richer in both α-chaconine and in α-solanine (Gregory, 1984; Lisińska & Leszczyński, 1989; Love et al., 1994; Papathanasiou et al., 1998; Sinden et al., 1984). Moreover, immature tubers regardless of their size, have greater tendencies to accumulate glycoalkaloids.

Investigations carried out by some authors (Sinden et al., 1984) show that fast maturing in potato tuber varieties, the level of glycoalkaloids decreases as early as about 50 days after vegetation begins.

Higher glycoalkaloid contents in potatoes harvested in the first period can also be due to a greater influence of unfavourable environmental and weather conditions, including low air temperature. These factors, together with the shorter vegetation period of the tubers, can influence the glycoalkaloid contents in a negative way (Lisińska & Leszczyński, 1989; Love et al., 1994; Maga, 1980; McCay et al., 1987; Sinden et al., 1984).

4. Conclusions

Investigated tuber samples of *Aster*, *Mila* and *Bryza* varieties differed in glycoalkaloid contents, as well as in the ratio of α-chaconine to α-solanine comprising them. The greatest amounts of glycoalkaloid, in general, were contained in the very early *Aster* variety while the lowest amounts were in the middle-late *Bryza* variety. Tuber samples contained α-chaconine and α-solanine in ratios from 2:1 (*Mila* variety) to 4:1 (*Aster* variety). The peeling of tubers caused decreases of α-solanine and α-chaconine contents in the investigated potatoes and obscured differences between varieties. The contents of these compounds in peeled tubers of studied potato varieties were always at a similar, low level, regardless of the glycoalkaloid contents in tubers before peeling. After a delay of the harvest date, glycoalkaloid contents in the investigated tuber samples decreased, to the greatest extent in the case of very early *Aster* variety. Investigated tuber samples all had glycoalkaloid concentrations safe for human health, regardless of the harvest date or potato variety.

References

AACC. (1968). *American Association of Cereal Chemists approved methods* (7th ed.). St. Paul: Minn.

Bejarano, L., Mignolet, E., Devaux, E., Carrasco, E., & Larondelle, Y. (2000). Glycoalkaloids in potato tubers: the effect of variety and drought stress on the α-solanine and α-chaconine contents of potatoes. *Journal of Science and Food Agriculture*, *80*, 2096–2100.

Bushway, R. J., Bureau, J. L., & McGann, D. F. (1983). Alpha-chaconine and alpha-solanine content of potato peels and potato peel products. *Journal of Food Science*, *48*, 84–86.

Gregory, P. (1984). Glycoalkaloid composition of potatoes: diversity and biological implications. *American Potato Journal*, *61*, 115–122.

Haddadin, M. S. Y., Humeid, M. A., Quaroot, F. A., & Robinson, R. K. (2001). Effect of exposure to light on the solanine content of two varieties of potato (Solanum tuberosum) popular in Jordan. *Food Chemistry*, *73*, 205–208.

Kuc, J. (1984). Steroid glycoalkaloids and related compounds as potato quality factors. *American Potato Journal*, *61*, 123–140.

Leszczyński, W. (1994). Ziemniak jako produkt spozywczy (The potato as a food product). *Postępy Nauk Rolniczych*, *1*, 15–29.

Lisińska, G., & Leszczyński, W. (1989). *Potato science and technology*. London and New York: Elsevier Applied Science.

Love, S. L., Herrman, T. J., Thompson-Johns, A., & Baker, T. P. (1994). Effect and interaction of crop management factors on the glycoalkaloid concentration of potato tubers. *Potato Research*, *37*, 77–85.

Maga, J. A. (1980). Potato glycoalkaloids and related compounds as potato quality factors. *American Potato Journal*, *61*, 123–139.

McCay, C. M., McCay, J. B., & Smith, O. (1987). The nutritive value of potatoes. In W. F. Talburt, & O. Smith (Eds.), *In Potato processing*. (4th ed.). (pp. 297–299). New York: Van Nostrand Reinhold.

Papathanasiou, F., Mitchell, S. H., & Harvey, B. M. R. (1998). Glycoalkaloid accumulation during tuber development of early potato cultivars. *Potato Research*, *41*, 117–124.

Rogozińska, I., & Wojdyła, T. (1999). Der Einfluß variierter Düngung, einer Pflanzenschutzmittel-Anwendung und der Lagerung auf den Glykoalkaloid-Gehalt in Kartoffelknollen zweier Sorten. *Potato Research*, *42*, 79–88.

Saito, K., Horie, M., Hoshino, Y., & Nose, N. (1990). High-performance liquid chromatographic determination of glycoalkaloids in potato products. *Journal of Chromatography*, *508*, 141–147.

Sinden, S. L., Sanford, L. L., & Webb, R. E. (1984). Genetic and environmental control of potato glycoalkaloids. *American Potato Journal*, *61*, 141–156.

Speijers, G.J.A. 1998. Risk assessment of potato-glycoalkaloids. AIR NETTOX Project Seminar Report 7. Published by Danish Veterinary and Food Administration, Søborg, Denmark, 43–47.

Wilska-Jeszka, J. (1994). Inne naturalne sktadniki zywności (Natural Food Components). In Z. Sikorski (Ed.), *Chemiczne i funkcjonalne właściwości składników zywności* (Chemical and functional properties of food components). (pp. 431–482). Warszawa: WNT.

Wunsch, A., & Munzert, M. (1994). Einfluss von Lagerung und Sorte auf die Verteilung der Glykoalkaloide in der Kartoffelknolle. *Potato Research*, *37*, 3–10.