Food Chemistry **49** (1994) 233–235

The effect of naturally occurring vitamin C in potato tubers on the levels of nitrates and nitrites

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(Received 7 January 1993; revised version received and accepted 22 April 1993)

Five varieties of table potatoes were tested with respect to the contents of ascorbic acid, nitrates and nitrites. The potatoes were characterized by a medium level of vitamin C (16·4 mg/100 g) and nitrates (294 mg KNO_3/kg), and a high level of nitrites (0·70 mg $NaNO_2$/kg). A significant effect of cultivation year on the content of vitamin C and nitrates in the tubers has been observed. The highest level of vitamin C was displayed by the variety Mila which had the lowest content of nitrates. Statistical analysis has shown a significant correlation between the natural content of ascorbic acid and the level of nitrates in potato tubers.

INTRODUCTION

Some nitrate and nitrite changes occurring in a number of higher plants, are the result of the activity of nitrate and nitrite reductases found both in leaves and roots.

In model studies it was found that a supplement of vitamin C showed an activating effect on nitrate reductase in white cabbage (Heród-Leszczyńska and Międzobrodzka, 1992) whereas Basu *et al.* (1984) have shown that a supplement of ascorbic acid to a pickling mixture automatically resulted in a reduced concentration of nitrites. The authors suggest that this phenomenon is an outcome of a reduction of nitrites to nitrogen oxide through the action of ascorbic acid.

It is not unlikely that vitamin C, naturally occurring in vegetables, can exhibit a similar activity with respect to nitrates and nitrites contained in them, this effect being dependent, among other things on the vitamin C concentration (Massey *et al.*, 1982; Vogtmann *et al.*, 1987).

Thus studies were undertaken on the effect of the naturally occurring vitamin C in potato tubers on the levels of nitrates and nitrites.

MATERIAL AND METHODS

Material

The investigation made use of five varieties of potatoes cultivated in 1989–1991 in the Experimental Station of Varieties Evaluation at Węgrzce near Kraków. The following varieties were tested: mid-early varieties Mila and Fauna as well as late varieties Atol. Bryza and Uran. Tuber testing was done after an initial 2-week storage period. Tuber samples were washed, peeled and comminuted. To determine the content of ascorbic acid, the tubers were disintegrated in 2% oxalic acid.

Methods

The content of nitrites in tubers was determined by the colorimetric method with sulphanilic acid and that of nitrates, after being reduced into nitrites, by metallic cadmium (Tyszkiewicz, 1986).

The determinations were done in six replications. The vitamin C level was determined as a sum of L-ascorbic acid and dehydroascorbic acids by the colorimetric method of Tilmans modified by Pijanowski (Rutkowska, 1981).

The results were calculated statistically using analyses of variance and regression as well as correlations.

RESULTS AND DISCUSSION

The content of nitrates in potatoes was in the range 85–843 mg KNO_3/kg fresh matter of tubers, averaging 297 mg/kg (Fig. 1). In accordance with the findings of other authors (Grassert *et al.*, 1990; Międzobrodzka *et al.*, 1992) a statistically significant correlation was found between the nitrate level in tubers and the year of cultivation. The highest mean content of nitrates of all varieties, 454 mg/kg, was displayed by potatoes cultivated in 1991. Potatoes originating from other years of cultivation were characterized by statistically lower levels of nitrates, amounting to 260 mg/kg in 1990 and 170 mg/kg in 1989. Statistically significant

Food Chemistry 0308-8146/94/$07.00

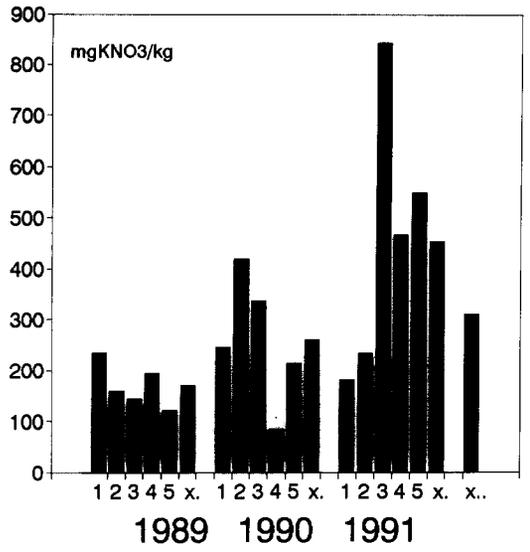

Fig. 1. The content of nitrates in potatoes of five varieties cultivated in the years 1989–1991.

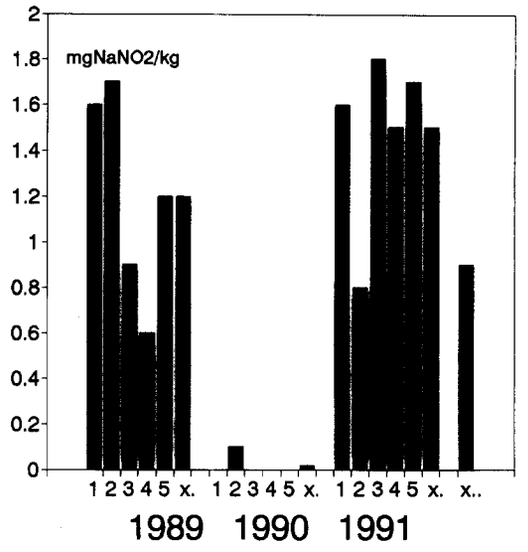

Fig. 2. The content of nitrites in potatoes of five varieties cultivated in the years 1989–1991.

differences were also found between the nitrate levels of varieties under cultivation. The lowest mean value for nitrate level of 3 years of cultivation, 220 mg/kg, was exhibited by a mid-early potato variety, Mila, while the highest one, 440 mg/kg of tuber, was characteristic of a late variety, Atol.

The level of nitrites in the potatoes throughout the study period was in the range from 0·0 to 1·8 mg $NaNO_2$/kg averaging 0·70 mg/kg (Fig. 2). The highest level of nitrites, as for nitrates, was recorded in 1991. The high level of nitrites in the studied potatoes may raise objections since most investigators have observed considerably less or even trace amounts of these compounds in freshly harvested vegetables (Grassert *et al.*, 1990; Hippe and Müller, 1984). However, in the tubers of potatoes cultivated in Poland (a high level of nitrites is found (Baryłko-Pikielna and Tyszkiewicz, 1991; Karłowski *et al.*, 1988; In all probability high levels of nitrites in tubers are formed in the period which elapses from their harvest to the moment of their analyses when, due to the poor condition of the tubers, many of the developing bacteria are able to reduce nitrates to nitrites (Więckowska *et al.*, 1981).

From the literature it appears that the chemical composition of tubers depends, among other things, on their physiological condition and an infestation of tubers with viral diseases results in an accumulation of non-protein nitrogen (Leszczyński *et al.*, 1984).

Studies have shown that potatoes originating from the 1989 and 1991 years of cultivation are characterised by a considerably higher level of nitrites than those of 1990 and some varieties cultivated in the years 1989 and 1991 were very seriously affected by softrot. After germination many tubers were removed from the study areas due to a very severe infestation by black leg while in August potato blight emerged.

The content of ascorbic acid in the studied potatoes averaged 16·4 mg/kg and was in the range 11·8–27·1 mg/100 g (Fig. 3). Vitamin C contents in tubers showed significant differences between years of cultivation and between varieties. The highest average level over 3 years of cultivation was exhibited by variety Mila. At the same time the nitrate content in tubers of this variety proved to be the lowest over 3 years of cultivation.

The results obtained were calculated statistically. A negative correlation was found between the content of ascorbic acid occurring naturally and that of nitrates in tubers. An activating effect of vitamin C on nitrate reductase and thus on a reduction of nitrates was also observed by other authors (Massey *et al.*, 1982; Heród-Leszczyńska and Międzobrodzka, 1992).

The correlation coefficient (−0·22), however, is not indicative of a linear correlation between vitamin C and nitrates. The reason for the lack of highly significant differences between the studied constituents of the tuber is probably the great variability characteristic of potato (Table 1), which is determined by genetic and environmental factors. It has already been observed

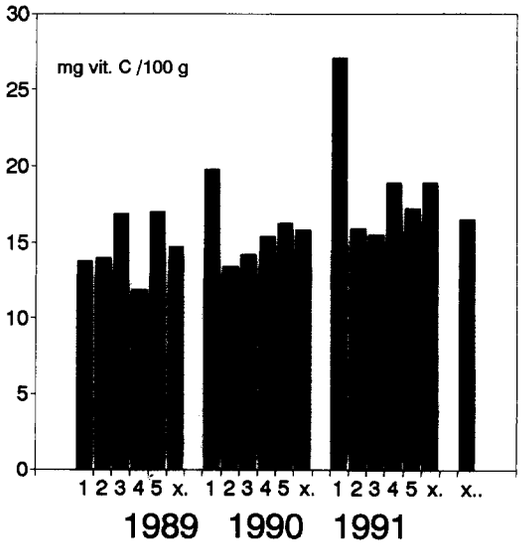

Fig. 3. The content of vitamin C in potatoes of five varieties cultivated in the years 1989–1991.

Table 1. Range and mean content of vitamin C, nitrates and nitrites in potatoes (means of five varieties and 3 years of culti vation)

Item	Vitamin C (mg/100 g)	Nitrates (mg KNO_3/kg)	Nitrites (mg $NaNO_2$/kg)
Range	11·8–27·1	85–848	0·0–1·8
Mean	16·4	295	0·70
Standard deviation	3·54	198	1·1
Variability coefficient (%)	21·6	67·1	30·5

that such factors can be responsible for far-reaching disturbances in the development of the tubers and the physiological processes involved, which finally affect the levels of nutritive and non-nutritive components in the potatoes (Roztropowicz, 1971).

The calculated coefficient of multiple correlation ($R = 0{\cdot}71$) shows a significant difference between the content of vitamin C and that of nitrates, taking into consideration variabilities between years of potato cultivation. Based on the analysis of regression the following equation was produced:

$$y = 317{\cdot}5 - 25{\cdot}1x_4 + 194{\cdot}3x_1$$
$$(101{\cdot}9)\quad (6{\cdot}9)\quad (29{\cdot}8)$$

where

y = content of nitrates,
x_4 = content of vitamin C,
x_1 = year of cultivation.

The coefficients of the above equation allow us to infer that a vitamin C increment by one unit (for a given year) will result in a decrease in nitrate level by an average of 25·1 units. In addition, the error obtained for that regression coefficient, estimated at 6·9 units, allows us to conclude that there is a statistically significant effect of vitamin C level on nitrate content since the value of the Student's T-test calculated in this case would amount to 3·64.

Likewise, the effect of year can be estimated. As follows from the equation, each consecutive year caused (for a given level of vitamin C) an increase in nitrate level by an average of 194·3 units. Some fluctuations about that value within 29·8 units allow us to consider the effect of year as statistically significant ($T = 6{\cdot}52$).

Statistical analysis of nitrites did not show any significant effect of vitamin C on the content of these compounds in potato tubers.

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