Fluoride Accumulation in Selected Vegetables During Their Vegetation

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Abstract

We observed, both in the leaves and roots of the vegetables examined, that the concentration of fluoride was in each case higher in vegetable samples in Łosień, 6 km from the "Katowice" Steel Works (fluorine emitters), than in the vegetable samples grown in Nowy Sącz, 200 km from the "Katowice" Steel Works (in the area of relatively low fluorine pollution). The highest F content was characteristic of beet (*Beta vulgaris*) leaves and root samples, the lower one was found in celery (*Apium graveolens*) leaves and root samples and the lowest one in savoy (*Brassica oleracea*) leaf samples. The highest and lowest F^- concentrations in the leaf samples examined was c.a. 33 mg/kg D.W. (beet leaves from Łosień of 1995) and c.a. 11 mg/kg D.W. (savoy leaves from Nowy Sącz of 1996). Moreover, it was found that the observed growth of F^- concentration in the savoy leaf samples, both from Łosień and Nowy Sącz, correlated with an increase of nitrogen concentration in them.

Keywords: fluoride in vegetables, fluoride and nitrogen, pollution aspect

Introduction

Vegetables absorb fluorine, both from the soil and air, as well as from falling atmospheric dust [1,2]. The effect on its content in vegetables may result from various factors, among other things, its compound growth of industrial emissions in the environment, species characteristics and even features of individual vegetables with their course of vegetation process [1-3].

In 1995 and 1996 the fluorine content in some vegetables grown in the household gardens within the reach of the "Katowice" Steel Works was examined [4]. Currently, the results obtained in the research are being analyzed from the viewpoint of the vegetation condition in the vegetables analyzed, as well as the dependence of F^- concentration on nitrogen content in the samples examined.

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Materials and Methods

The leaves and roots of beet (*Beta vulgaris*) and celery (*Apium graveolens*) were examined, as well as those of savoy (*Brassica oleracea*). In the leaves and roots samples prepared properly in 1995 and 1996, the fluorine content was determined (in the form of F^- concentration) and, in the savoy leaf samples of 1996, nitrogen content. The samples of 15 randomly selected vegetable items were examined. The samples came from household gardens located in Łosień within 6 km of the "Katowice" Steel Works and from the inspection area (relatively low in fluorine compound pollution), within the distance of 200 km from the "Katowice" Steel Works, in the city of Nowy Sącz. In those gardens, between the years 1994-1996, no mineral fertilization was applied. The fluorine determinations were carried out for 15 parallel samples of each kind. The material for these determinations was prepared in accordance with the Machoy method [5].

Table 1. The average* F^- concentration in vegatable leaf and root samples from Łosień and Nowy Sącz in 1995 and 1996**.

Year, city	Sample sorte	*Beta vulgaris*	*Apium graveolens*	*Brassica oleracea*
1995, Łosień	leaves	33.33 ± 1.75	27.52 ± 0.70	21.81 ± 0.51
1995, Nowy Sącz		23.54 ± 0.80	23.1 ± 0.51	18.18 ± 0.23
1995, Łosień	roots	29.04 ± 1.87	25.94 ± 0.46	-
1995, Nowy Sącz		15.91 ± 0.67	15.19 ± 0.89	-
1996, Łosień	leaves	23.19 ± 1.47***	23.29 ± 2.17	17.97 ± 1.03
1996, Nowy Sącz		19.73 ± 0.94***	11.52 ± 1.40	10.83 ± 0.49

Explanation: *in mg/kg dry weight (D.W.); **for the examined vegetable vegetation period - the determination was carried out after 2, 4 and 6 months of vegetation, i.e.in July, September and November, in each case for 15 samples of each kind (each results in Table 1 is the average of 45 determinations and is given with SD); *** the difference statistically insignificant $p > 0.05$.

The F^- ions were determined potentiometrically using a fluorine selective electrode by means of OP-262 manufactured by Radelkis company.

Nitrogen determinations were carried out for 5 parallel savoy leaf samples of 1996 using the Dumas method [6].

Results and Discussion

The F^- concentration determinations in the vegetables examined were carried out after 2, 4, and 6 months of their vegetation, i.e. in July, September and November 1995 and 1996. The average F^- content values calculated for that period are shown in Table 1, whereas Table 2 shows the evaluation of the correlation in the time function of the vegetation duration of the vegetables examined. It was found that the average F^- content in the leaves of the vegetables examined (Table 1) was significantly higher in 1995 as compared with 1996. Simultaneously, both in the leaf and root samples, the F content in each case was higher for the vegetables grown in Łosień, near the "Katowice" Steel Works. Apart from the cases, in which the lack of essential difference in F^- concentration in the beet and celery leaves was observed (Table 1), the highest F^- content was characteristic of the beet leaves and roots, the lower one was discovered in the celery leaf and root samples, and the lowest one F^- content was found in the savoy leaf samples. The highest and the lowest F^- concentration in the leaf samples was c.a. 33 mg F^-/kg D.W. (the beet leaves from Łosień 1995) and c.a. 11 mg F^-/kg D.W. (the savoy leaves from Nowy Sącz 1996).

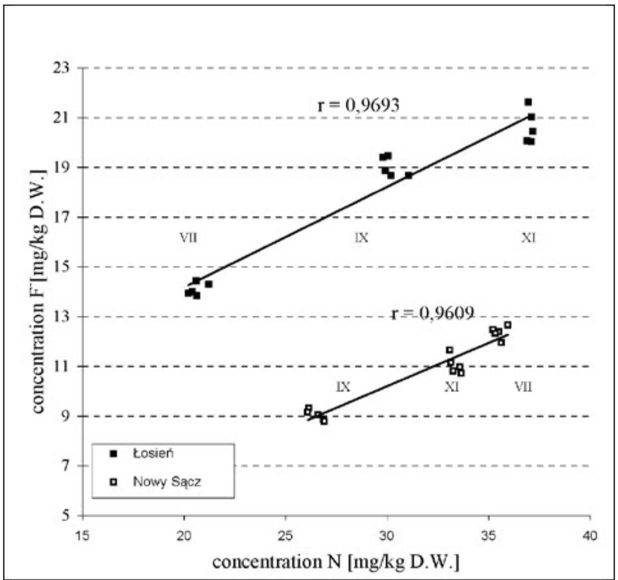

Fig. 1. Correlation between N and F-concentration in the savoy from Łosień and Nowy Sącz of 1996.
VI - July, IX - September, XI - November

The F^- content in the beet root and celery roots, both from and in Nowy Sącz equalled its content in the leaves of those vegetables. Table 2 shows the values of directional ratio of 'a' directional ratio and 'r' correlation ratio of the obtained (linear) regression equations indicating an increase or decrease in F^- concentration during the vegetation of the vegetables examined. The value of 'b' absolute term in Table 2 means average F^- concentration determined in the vegetable samples collected in July 1995 and 1996. The positive correlation (increasing one) was obtained for the leaf samples (r=0.56÷0.96) and roots (r=0.47 and 0.64) of all the vegetables grown in Łosień and for the vegetable leaf samples from Nowy Sącz, but from the year 1995 only (r=0.39÷0.93). In other cases pertaining to the leaf samples of 1996 and the root samples of 1995 coming form Nowy Sącz, the correlation was negative (for the leaves r=-0.32 and -0,81 and for the roots r=-0.65 and –0.82 respectively). This may be associated with lesser (as compared with Łosień) air pollution with fluoride and possibly soil pollution in Nowy Sącz.

In the savoy leaf samples of 1996, the parallel N and F^- concentrations were determined (F^- ion). The results presented in Table 3 indicate that the observed growth in F^- concentration in each case correlated with the increase of N concentration in the samples examined. This correlation is shown in Figure 1. In case of the samples from

Table 2. Correlation between F^- concentration in the vegetable samples from Łosień and Nowy Sącz and time of vegetation duration*.

Year, city	Sample		$y_{(F_{conc})} = a + b_{(months)}$		
			a	b	r
1995, Łosień	leaves	beet	23.17	2.53	0.81
		celery	23.39	1.03	0.63
		savoy	18.04	0.82	0.56
1995, Nowy Sącz	leaves	beet	18.28	1.28	0.77
		celery	14.88	2.06	0.93
		savoy	16.68	0.38	0.39
1995, Łosień	roots	beet	21.25	2.00	0.64
		celery	13.27	0.68	0.47
1995, Nowy Sącz	roots	beet	29.27	-0.83	-0.65
		celery	20.56	-1.46	-0.82
1996, Łosień	leaves	beet	16.92	1.57	0.58
		celery	8.80	3.63	0.96
		savoy	11.41	1.64	0.89
1995, Nowy Sącz	leaves	beet	19.92	-0.06	-0.04**
		celery	19.23	-1.91	-0.81
		savoy	12.21	-0.34	-0.32

Explanation: *determined subsequently in July, September and November; being subsequently 2, 4 and 6 months;
**r critical value $_{(0.05)}$ (43) = 0.30.

Table 3. F^- and N concentration* in the savoy leaves from Łosień and Nowy Sącz in 1996**.

Concentration [mg/kg D.W.]	Łosień			Nowy Sącz		
	July	September	November	July	September	November
F^-	14.11 ± 1.43	19.02 ± 1.47***	20.64 ± 2.59***	12.37 ± 1.00	9.04 ± 0.81	11.07 ± 1.43
N	20.61 ± 0.31	30.20 ± 0.35	37.04 ± 0.37	35.52 ± 0.35***	26.51 ± 0.46	33.34 ± 0.31***

Explanation: * in mg/kg dry weight (D.W.); ** determination averages results in 5 parallel samples given with SD value;
*** the difference statistically insignificant, p > 0.05 (Multi range test).

Łosień, the monotonous (from month to month) increase in nitrogen and F^- concentration was observed in the savoy samples examined in the month of July, September and November). The analogue increasing correlation in case of the savoy leaves from Nowy Sącz was observed after the suitable change in the series of increasing nitrogen and F^- concentrations (as shown in Table 3) (the increase of these concentrations took place subsequently in the samples of September, November and July).

Apart from the lack of time correlation of the results discussed that refer to the samples from Nowy Sącz, likewise, in the case of the savoy leaf samples from Łosień, a very good correlation was also obtained between the determined N and F^- concentrations.

The results discussed confirm the observations made earlier [7-9], proving the intensified F cumulating in plant organisms in the area of the “Katowice” Steel Works as the fluorine compounds emitter.

Fluorine may affect the food components taken from soil by plants in many different ways [2]. It is also known that nitrogen and phosphorus, as well as K^+ ions, Mg^{2+} and Ca^{2+} increase vegetables’ immunity to fluorine toxicity [10]. However, not much is known about the interdependence of N and F^- concentration in plants examined by us. Fluorine is an inhibitor of a series of enzyme [11], including vegetable enzyme [12], and it fixes covalently with protein [13, 14]. Due to nitrogen occurrence in protein (it is the characteristic feature of the savoy leaves to have relatively large protein content [15]), the observation of the correlation discussed between F^- and N concentration examined points at the fact that the level of F^- accumulation in vegetables may depend, among other things, on their protein content.

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