Bull. Environ. Contam. Toxicol. (2004) 72:109–113

DOI: 10.1007/s00128-003-0247-2

Environmental Contamination and Toxicology

Nitrate Content of Lettuce Grown in the Greenhouse

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Received: 2 April 2003/Accepted: 11 September 2003

Nitrates are present naturally in soils, water and plants as a consequence of nitrogen fixation. The wide use of nitrogen-based fertilizers in agriculture contributes to the total nitrate present in the environment as well. The significance of nitrate to human health derives from the fact that nitrate can be converted *in vivo* to nitrite producing toxic effects (Šebečić and Vedrina-Dragojević 1999). In addition, nitrite ion can react with secondary or tertiary amines to form N-nitroso compounds, some of them being implicated in the etiology of cancers (Anonymous 1996; Šebečić and Vedrina-Dragojević 1999). The ingestion of small doses of nitrate may cause cyanosis (methemoglobinemia) because of the reduction of nitrate to nitrite in the gastrointestinal tract. The acute toxicity of nitrites is due to their interaction with blood pigment to produce methemoglobinemia, and their presumptive toxicity is related to their possible reaction with amide or amides to form nitroso compounds (Sanchez-Echaniz 2001).

This results in difficulties in the oxygen transport by hemoglobin. Poisoning cases numbering in thousands have been reported, mostly involving poisoning in infants. Nitrate may be considered as the index of the amount of nitrite which may be formed (Abo Bakr et al.1986; Sanchez-Echaniz 2001).

The acceptable daily intakes (ADI) of nitrites and nitrates recommended by WHO are 0-0.06 mg NO_2^-/kg body weight, that is 0-3.7 mg NO_3^-/kg body weight. As a result of recent investigations, 75-80 % of the daily intake of nitrates derives from vegetables (Šebečić and Vedrina-Dragojević 1999; Ximenes et al. 2000).

The amount of nitrate markedly varies depending on the sort of vegetables, genetic factors, agricultural practices, climatic conditions, degree of maturity, and light (Gürses 1983).

High nitrate and nitrite content of raw consumed vegetables are especially important for infants who show a greater sensitivity to such compounds (Artık et al. 2002). Lettuce is one of the widespread consumed vegetables especially in winter. The nitrate content of lettuce was found as 430 mg/kg by Abo Bakr et al.1986; 0.20-11 304.00 mg/kg by Anonymous (1996); 317.36-1117.77 mg/kg by

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by Artık et al. (2002); 81-1123.5 mg/kg by Gülser et al. (1999); 428-1766 mg/kg by Santamaria et al. (1999); 457.61-8220.30 mg/kg by Ustun and Tosun (1998), and 1945 mg/kg by Ximenes et al. (2000).

The purpose of this study is to determine the nitrate content of lettuce grown under greenhouse conditions.

MATERIALS AND METHODS

Forty three samples of lettuces randomly collected from different greenhouses (28 in Çarşamba and 15 in Bafra porvince of Samsun) were analyzed. The harvested lettuce samples immediately brought to laboratory were sorted, washed with distilled water. The water was drained and they were blended in a Waring model mechanical blender.

Dry matter contents of the blended samples were determined by oven-drying at 105°C until a constant weight was obtained (AOAC 1984). The nitrates were spectrophotometrically assayed with the formation of diazo compound through the reduction of nitrate to nitrite by the addition of zinc powder and cadmium acetate (Kılıç et al. 1991).

RESULTS AND DISCUSSION

The nitrate amounts determined in lettuce are shown in Table 1.

The range of nitrate content was 139-5544 mg/kg (mean=2455 mg/kg). The average nitrate content of lettuce grown in Çarşamba and Bafra greenhouses was 2597 and 2190 mg/kg, respectively.

When the samples were formed into groups according to the nitrate contents (Figure 1), samples containing nitrate between 2000 and 3000 mg/kg had the highest ratio of percent distribution.

The nitrate content of the lettuce was higher than the values reported by the other researchers (Abo Bakr et al.1986; Artık et al. 2002; Gülser et al. 1999; Santamaria et al. 1999; Ustun and Tosun 1998; Ximenes 2000). The results of all samples are in agreement with Anonymous (1996).

Generally, the nitrate content of lettuce samples was higher than the values reported in the literature. This difference may due to harvest period, addition of fertilizers, temperature and light factors from the ecological environment. The high temperature and low light intensity increase the nitrate fixation of vegetables (Gülser et al. 1999; Steingrover and Steenhuizen 1993). Growing vegetables in greenhouses without artificial lightening increases nitrate content (Steingrover and Steenhuizen 1993).

Table 1. Nitrate content of lettuce.

Sample	Dry Matter (%)	Nitrate (mg/kg-Fresh weight)	Sample	Dry Matter (%)	Nitrate (mg/kg-Fresh weight)
1	4.79	2 649	**24**	5.35	4 345
2	4.32	3 288	**25**	4.57	1 923
3	4.49	4 004	**26**	4.32	5 544
4	4.58	2 566	**27**	3.74	3 152
5	4.99	2 142	**28**	4.46	1 063
6	4.24	3 015	**29**	4.02	2 102
7	5.19	139	**30**	4.53	2 184
8	3.79	2 682	**31**	4.52	2 604
9	6.09	425	**32**	4.90	3 465
10	4.53	2 077	**33**	3.87	2 124
11	4.58	2 856	**34**	4.54	2 100
12	4.19	2 134	**35**	4.01	2 448
13	4.63	2 041	**36**	3.95	2 577
14	5.22	2 018	**37**	4.30	3 505
15	4.12	3 011	**38**	4.82	2 444
16	5.05	2 937	**39**	5.00	1 781
17	4.00	3 382	**40**	3.52	1 501
18	4.07	2 910	**41**	4.63	900
19	4.82	3 133	**42**	4.77	1 583
20	5.71	1 899	**43**	3.67	1 541
21	4.88	1 218	**Max.**	**6.09**	**5544**
22	4.32	3 113	**Min.**	**3.52**	**139**
23	4.51	3 044	**Mean**	**4.53**	**2455**

Samples 1-28 from greenhouses in Çarşamba, 29-43 from greenhouses in Bafra

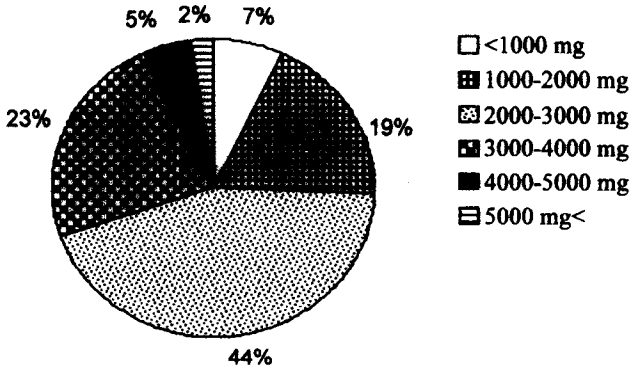

Figure 1. Percent distribution of lettuce according to nitrate content.

Compounding the complexity of nitrosamine formation in the body is the fact that significant amounts of nitrate are synthesized by normal physiological processes in humans. Evidence is beginning to accumulate that the endogenous formation of nitroso compounds may represent the largest general exposure to nitroso compounds, but it is not possible at present to qualify the amount of exposure. It is also becoming clear that diet may play a role in the types and amounts of nitroso compounds formed endogenously (Hotckiss and Cassens 1987).

The higher content of nitrates and nitrites are especially important in raw consumed vegetables, because cooking of fresh vegetables in boiling water has the effect of lowering their nitrate and nitrite contents due to leaching into the cooking water (Abo Bakr et al.1986; Sistrunk 1980). The high nitrate contents of lettuce is especially important for children and weak persons.

The dietary balance between nitrate and ascorbic acid may be particularly important because ascorbic acid is capable of inhibiting endogenous nitrosamine formation resulting from nitrate exposure (Hotckiss and Cassens 1987). So, a diet rich in ascorbic acid content may be suggested to be consumed with raw consumed vegetables having high content of nitrates as a precaution.

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