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Nitrate and nitrite levels in fresh and frozen broccoli. Effect of freezing and cooking

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Nitrite and nitrate levels in broccolis coming from different cultures from the south of Navarra (Spain) were analyzed. Fresh products had only traces of nitrites and low levels of nitrates (48–97 ppm KNO_3). Industrial freezing gave rise to an increase in the nitrate levels (127–232 ppm KNO_3), probably as a consequence of high levels in the processing water. Cooking decreased nitrate levels (between 22 and 79%), there being no differences in the levels of reduction between fresh and frozen vegetables. Nitrite levels were scarcely affected either by freezing or by cooking. Copyright © 1996 Elsevier Science Ltd

INTRODUCTION

Human dietary nitrate and nitrite exposure should be controlled as they may be considered a health risk factor. Although nitrates are relatively harmless to humans, their conversion to nitrites or other N-nitroso compounds may produce toxic products.

Nitrates are abundant in food primarily because plants take up nitrogen from the soil in this ionic form. The National Academy of Science (NAS, 1981), has estimated that vegetables provide 87% of the nitrate in a normal diet and has recommended a decrease in nitrate intake from vegetables. In some works it has been established that the nitrate content of many vegetables was excessive (Rutkwoska *et al.*, 1993; Gajda & Karlowski, 1993) and the need for the permanent and systematic control of nitrates has been emphasized (Gajda & Karlowski, 1993). This is particularly important if it is borne in mind that vegetables are in the composition of most babies' menus where they will be the main source of these compounds (Contreras & Montes, 1994).

Nitrate levels in vegetables are known to vary considerably according to growing conditions: biological fertilization (Koval'chuk & Ponomarev, 1993; Schuster & Lee, 1987; Lairon *et al.*, 1984; García *et al.*, 1982), types of N fertilizers (Aktas *et al.*, 1993), hydroponic cultures (Lyons *et al.*, 1994), soilless cultures (Künsch *et al.*, 1994), harvesting season (Wawrzyniak *et al.*, 1993) and light and temperature conditions (Nieuwhof, 1994). Levels also vary with the vegetative parts (Ponomarev & Koval'chuk, 1991) and the storing conditions (Yang, 1992).

In vegetables that need to be cooked, the effect of the boiling is of concern (Bosch & García, 1988; García & Bosch, 1988*a*; Astier-Dumas, 1976). Industrial processing can also affect nitrate and nitrite contents (Bednar *et al.*, 1991), with blanching being one of the main change factors (Sistrunk, 1980). As fresh vegetables are frequently replaced by frozen ones, their nitrate and nitrite contribution should also be taken into account.

The objectives of this study were to determine nitrate and nitrite levels in fresh and frozen broccoli (*Brassica oleacea*) and the effect of cooking on both types of product.

MATERIALS AND METHODS

Fresh and frozen samples

Samples of broccoli were harvested in autumm from five different cultures (five lots) from the south of Navarra (Spain). The batches were frozen by an industrial process which included a steam blanching with micronized water showers for 3 mins. Subsequently samples were water quenched to freezing at −20 °C. From each batch, four aliquots of fresh, blanched and frozen vegetables were taken. Fresh and blanched samples were analyzed inmediately. Frozen samples were held under refrigeration for one day.

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Methods

Moisture was determined by desiccation at 105°C (AOAC, 1995). Nitrite levels were determined according to the method of Nicholas & Nason (1957) using sulfanilamide and N-(1 naphthyl) ethylenediamine hydrochloride and reading the absorbance at 540 nm.

Nitrates were determined by previous reduction to nitrites using the method of Kramlich *et al.* (1973). Both methods are described by AOAC, 1995.

Cooked samples

65 g of fresh and frozen samples were boiled in 500 ml of deionized water for 10 mins. Cooking liquids were filtered (through Whatman N^{o} 40), separated from the product and clarified.

Data analysis

The data shown are the means obtained from the four analyzed samples together with the standard deviations. Differences between means were calculated by analysis of variance and Tukey test (more than two samples) or by Student's *t* test (two samples). Comparisons were carried out between samples (a,b,c,...), and between different technological phases (A,B,...).

RESULTS AND DISCUSSION

Fresh vegetables

Tables 1 and 2 show the levels of nitrites and nitrates in the fresh analyzed samples. As was expected, significant differences between some samples from different cultures can be observed.

In none of the cases was the nitrite content over 1 ppm. Nitrate levels ranged from 48.9–97.1 ppm. Neither Corsi *et al.* (1981) nor Schuster & Lee (1987) detected nitrites in fresh broccoli and they found 606 ppm and 520 ± 497 mol/100 g of nitrates, respectively. Lisiewska (1986) found 1.4 ppm of nitrites and 522 ppm of nitrates and Lisiewska & Kmiecik (1991) found 0–1.07 ppm of nitrites and 16-44 ppm of nitrates. Thus, it can be said that the analyzed samples are of a good quality as far as their nitrite and nitrate content is concerned. These samples were harvested in autumm and this could be the reason for their low levels, as was established by Boon *et al.* (1990). In contrast to information obtained from other vegetables (Siciliano *et al.*, 1975; García & Bosch, 1988*b*; Ruiz *et al.*, 1988; Domínguez, 1994) the nitrite and nitrate levels could also be considered low.

Frozen vegetables

Industrial processing, including blanching, can affect retention of nutrients and also nitrates. There are many papers which evidence a significant decrease of nitrates following a blanching operation. Gawecka (1974), determining nitrate content in spinach, found losses of 81.7% to 90.0% depending on the method of blanching. Niedzielski & Mokrosinska (1993) observed a drop of 47.5% in the nitrate content of frozen brussels sprouts as compared to the fresh product as a consequence of the effect of blanching. In contrast, Schuster & Lee (1987) did not find nitrate losses in blanched carrots and Miedzobrodzka *et al.* (1992) found that nitrates fell about 2.4–17.6% and nitrites rose about 26.9–85.2% in blanched carrots.

From the moisture percentages (Table 3) the nitrate levels referred to dry matter have been calculated throughout the freezing process (Fig. 1). A significant increase of nitrates with blanching and freezing can be observed. Also Lisiewska & Kmiecik (1991) stated that nitrates tended to increase during freezing. Tables 1 and 2, show that nitrite levels were scarcely affected by the freezing process, whereas nitrate levels increased significantly. These unexpected increases in nitrates with blanching could be explained by high levels of nitrates in the water employed in the process. Thus, it can be concluded that a strict control of water quality is necessary to guarantee the safety of the product. However, although the increase was significant, it did not lead to excessive nitrate levels. Contents in frozen broccolis (spears and chopped) cited in the bibliography

Table 1. Nitrite content in broccoli (ppm of $NaNO_2$)

	1	2	3	4	5
Fresh	ND	ND	< 1	ND	< 1
Frozen	3.41 ± 0.08	ND	1.77 ± 0.07	1.77 ± 0.28	1.00 ± 0.06

ND: Not detected.

Table 2. Nitrate content in broccoli (ppm of KNO_3)

	1	2	3	4	5
Fresh	$^{a}48.9 \pm 2.6^{A}$	$^{c}80.7 \pm 2.2^{A}$	$^{d}97.0 \pm 2.4^{A}$	$^{a}49.6 \pm 3.0^{A}$	$^{b}66.3 \pm 3.5^{A}$
Frozen	$^{c}166.2 \pm 4.7^{B}$	$^{d}220.8 \pm 13.2^{B}$	$^{d}231.2 \pm 8.6^{B}$	$^{a}127.3 \pm 9.2^{B}$	$^{b}141.6 \pm 3.6^{B}$

Any two means followed by the same letter in the same line or column are not significantly different at $p > 0.01$.

Table 3. Moisture (%) of fresh, blanched and frozen samples

	1	2	3	4	5
Fresh	90.09 ± 0.40	89.07 ± 0.70	89.43 ± 0.37	90.07 ± 0.12	88.65 ± 0.16
Blanched	91.47 ± 0.08	90.03 ± 0.19	91.30 ± 0.13	92.78 ± 0.10	92.15 ± 0.15
Frozen	92.24 ± 0.11	91.97 ± 0.06	91.84 ± 0.25	90.36 ± 0.16	91.43 ± 0.11

Table 4. Contents of $NaNO_2$ (ppm) in cooked broccoli

	1	2	3	4	5
Fresh	$^{a}1.94 \pm 0.70^{A}$	$^{b}3.81 \pm 0.71$	< 1	< 1	$^{a}2.25 \pm 0.03^{A}$
Frozen	$^{a}1.20 \pm 0.05^{A}$	< 1	$^{b}2.25 \pm 0.05$	$^{c}2.55 \pm 0.10$	$^{a}1.20 \pm 0.05^{B}$

Any two means followed by the same letter in the same line or column are not significantly different at $p > 0.01$.

Table 5. Contents of KNO_3 (ppm) in cooked broccoli

	1	2	3	4	5
Fresh	$^{a}7.7 \pm 0.5^{A}$	$^{a}10.8 \pm 1.4^{A}$	$^{c}12.5 \pm 1.3^{A}$	$^{c}12.7 \pm 0.5^{A}$	$^{b}14.7 \pm 0.4^{A}$
Frozen	$^{c}61.4 \pm 0.4^{B}$	$^{b}30.6 \pm 0.7^{B}$	$^{c}62.5 \pm 11.4^{B}$	$^{d}70.7 \pm 4.2^{B}$	$^{a}35.5 \pm 2.6^{B}$

Any two means followed by the same letter in the same line or column are not significantly different at $p > 0.01$.

Table 6. Moisture (%) of cooked samples

	1	2	3	4	5
Fresh	93.50 ± 0.02	95.00 ± 0.83	95.79 ± 0.08	96.03 ± 0.28	92.89 ± 1.92
Frozen	92.85 ± 0.96	94.99 ± 0.04	93.59 ± 0.19	92.23 ± 0.18	90.93 ± 0.47

(Siciliano *et al.*, 1975) are 464 and 573 ppm of nitrates and 1 ppm of nitrites.

Culinary process

Nitrite and nitrate levels of fresh and frozen broccoli after cooking are shown in Tables 4 and 5. Nitrite levels remained as low as in samples without cooking.Cooking vegetables tends to decrease the nitrate content since nitrate is soluble and readily leaches into cooking liquids (Rutkwoska *et al.*, 1993). Indeed, a significant decrease in nitrates in both types of products, fresh and frozen, as a consequence of cooking can be observed (Table 5). Pickston *et al.* (1980) and Abo Bakr *et al.* (1986) found nitrate reductions of 14–79% in fresh vegetables when they were cooked.

Taking into account the moisture percentages of cooked products (Table 6), the nitrate retention referred to dry matter was calculated. Results are shown in Fig. 2. The percentage of retention ranges from 24.1 to 68.2% in fresh broccoli and from 22.2 to 79.1% in frozen broccoli. García & Bosch (1988*a*) pointed out that nitrate diffusion into cooking water is not a function of the time of cooking but of the type of vegetable. Cieslik (1992) noted that the method of cooking influenced the percentage of nitrates and nitrites in potatoes. In our case, differences in the retention percentages were found in spite of the same cooking method being employed. It has to be pointed out that no differences can be established in the diffusion process of nitrates between fresh and frozen broccolies.

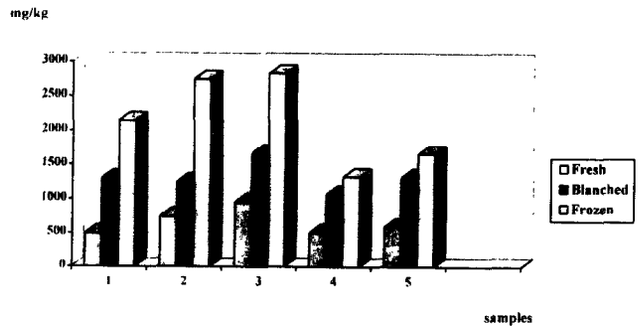

Fig. 1. Content of KNO_3 (mg/Kg of dry matter) in fresh and frozen broccoli.

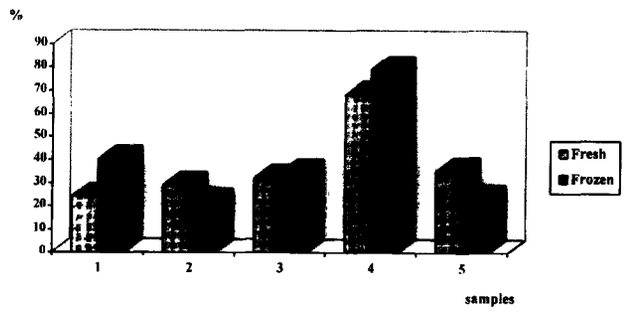

Fig. 2. Percentage of nitrate retention (referred to dry matter) in fresh and frozen cooked broccoli.

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