Journal of Food Composition and Analysis 22 (2009) 315–321

Contents lists available at ScienceDirect

Journal of Food Composition and Analysis

journal homepage: www.elsevier.com/locate/jfca

Original Article

Effects of some processing methods on nitrate and nitrite changes in cruciferous vegetables

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ARTICLE INFO

Article history:
Received 18 January 2008
Received in revised form 14 October 2008
Accepted 30 October 2008

Keywords:
Cruciferous vegetables
Blanching
Boiling
Freezing
Nitrate
Nitrite
Food processing
Cooking methods
Food contamination
Food safety
Food composition

ABSTRACT

Changes in nitrate and nitrite content in selected cruciferous vegetables, resulting from blanching, boiling, freezing, frozen storage and boiling after previous freezing, were analyzed. The highest level of nitrate was detected in curly kale (302.0 mg/kg) and the lowest in green cauliflower (61.0 mg/kg). As for nitrite, the respective levels were found in white cauliflower (3.49 mg/kg) and green cauliflower (1.47 mg/kg). Both blanching and boiling of the cruciferous vegetables caused a considerable decrease in the total nitrate content, but at the same time no explicit changes were noted regarding the level of nitrite. In the vegetables stored frozen for 48 h, previously blanched, either an increase or no change was observed in the nitrate level, with the changes in the nitrite level being irregular. In the vegetables stored frozen for 4 months, previously blanched, generally a decrease was noted in the nitrate, and an increase in the nitrite level compared to the levels in the blanched vegetables. Boiling of the frozen vegetables (stored frozen for 48 h) most frequently caused a considerable reduction of the nitrate level in comparison to the content in the raw frozen vegetables. No changes were observed resulting from the boiling of the vegetables previously stored frozen for 4 months. Simultaneously, no explicit changes were found regarding the nitrite level in the frozen vegetable after boiling.

1. Introduction

Nitrite and indirectly nitrate consumed with food in excessive quantities can be harmful to health. Among other things, they can convert haemoglobin into methaemoglobin and reduce nutritional value of the foodstuffs through negative impact on the bioavailability of vitamin A, the B-group vitamins, iodine and protein. Moreover, they are the precursors of the carcinogenic N-nitroso compounds. The main source of nitrate (75–87% of the total quantity) and nitrite (16–43%) in the diet is from vegetables (Amr and Hadidi, 2001; Szponar and Traczyk, 1995). The cruciferous vegetables are characterized by average (white cabbage) or low (cauliflower, Brussels sprouts) levels of these compounds; however, because they are consumed in large quantities and frequently, they can become a significant source of these compounds in the daily diet. These seasonal vegetables may be stored raw either for short (curly kale, broccoli, cauliflower) or long (Brussels sprouts) periods of time. Some of them can be eaten raw or after conservation by pickling or freezing (Gębczyński, 2003). The level of nitrate and nitrite content in raw plant material is not in direct proportion to their actual uptake, as both initial handling of the vegetables (washing and peeling) and cooking techniques may affect the final levels these compounds (Amal, 2000; Czarniecka et al., 1993; Huarte-Mendicoa et al., 1997; Kmiecik et al., 2004; Michalik and Bąkowski, 1997; Niedzielski and Mokrosińska, 1992).

The aim of this work was to determine the content and changes in the nitrate and nitrite levels in the selected cruciferous vegetables under the influence of the following processes: blanching, boiling, freezing, frozen storage, and boiling of the previously prepared frozen vegetables.

2. Materials and methods

2.1. Material

Five common cruciferous vegetables: curly kale (cv. Winter Bol), broccoli (cv. Sebastian), white cauliflower (cv. Rober), green cauliflower (cv. Amfora) and Brussels sprouts (cv. Maczuga), were obtained from Krakowska Hodowla i Nasiennictwo Ogrodnicze “Polan”, Poland, in 2004. The vegetable samples were taken for analyses directly from the field. Plants (5 kg green mass) were cut

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doi:10.1016/j.jfca.2008.10.025

vertically into four or eight pieces after removing inedible parts (e.g. leafy parts). The samples were further divided into four sub-samples, which were subsequently used to obtain (a) fresh, (b) blanched, (c) boiled, and (d) frozen (blanched and stored for 48 h and for 4 months at −22 °C in hermetic packages) vegetables. The fresh vegetables were obtained by washing the vegetables fresh from the field under running tap water and drying on filter paper.

Blanching was carried out at 80 °C for approximately 3 min to inactivate any enzymes present. All frozen vegetables were first blanched. After letting them cool at room temperature (about 20 min), they were packed to polyethylene bags and stored in a box freezer (Liebherr, Germany) (storage temperature −220 °C).

The vegetables (both raw and frozen) were cooked without using salt, in stainless-steel pots, until ready for consumption (about 10–15 min), at the temperature of around 100 °C, without a lid in the beginning phase of the process. The water volume to vegetables ratio was approximately 2:1.

Each cooking process was repeated three times.

2.2. Analytical methods

The prepared vegetables were assessed for nitrate and nitrite content according to Polish national standard (PN 92/A-75112). Nitrate content was assessed using Griess I (sulfanilamide, Sigma–Aldrich) and Griess II (n-(1-Naphtyl)ethylene-diamine dihydrochloride, water solution, Sigma–Aldrich). The principle of this method is to cause a colour reaction of nitrite with n-(1-Naphtyl)ethylene-diamine dihydrochloride in acidic conditions, and to measure absorbance at wavelength 538 nm. Nitrate had to be reduced to nitrite before the beginning of colour reaction. The described research method is recognized and widely used in assays to determine the content of nitrate and nitrite in vegetables. As part of the quality control of the method, analyses of the same material were carried out in two laboratories. Among other factors, repetitiveness, reproducibility and linearity were tested. As part of the quality control in the present study, model materials with closely defined contents of nitrite were applied.

Dry matter of prepared samples of vegetables was determined the AOAC method (1995).

Chemical analysis for each prepared sample of vegetables was repeated three times.

2.3. Statistical analysis

The results were expressed as treatment means. The data were subjected to one-factorial analysis of variance, including five species (1 × 5) of raw cruciferous vegetables (Table 1) and seven processing techniques for each species (1 × 7) (Tables 2–4). The statistical model included: 5 species, 7 processing methods, 3 replications of each process and 3 replications of each chemical analysis. The differences between treatment means were evaluated using Duncan's multiple range test. Treatment effects and differences between treatment means were considered if sig-

Table 1
Results of one-way analysis of variance of nitrate and nitrite content changes in raw cruciferous vegetables (mg/kg).

Vegetables	Nitrate X ± SD[a]	Nitrite X ± SD
Curly kale	302.0 e ± 8.15	1.66 b ± 0.07
Broccoli	277.7 d ± 4.53	1.90 c ± 0.15
White cauliflower	171.2 c ± 3.02	3.49 e ± 0.04
Green cauliflower	61.0 b ± 5.94	1.47 a ± 0.10
Brussels sprouts	37.6 a ± 3.86	2.28 d ± 0.25

Differences between values signed this same letters are non-significant.
[a] SD: standard deviation.

Table 2
Changes of nitrate content in cruciferous vegetables exposed to various processing techniques (mg/kg).

Vegetables	Processing techniques: Row		Blanched		Boiled		Frozen (24 h)		Boiled after 24 h freezing		Frozen storage (4 months)		Boiled after 4-month frozen storage	
	Nitrite X ± SD[b]	Nitrite after revision of mass changes[a] X	Nitrite X ± SD	Nitrite after revision of mass changes X	Nitrite X ± SD	Nitrite after revision of mass changes X	Nitrite X ± SD	Nitrite after revision of mass changes X	Nitrite X ± SD	Nitrite after revision of mass changes X	Nitrite X ± SD	Nitrite after revision of mass changes X	Nitrite X ± SD	Nitrite after revision of mass changes X
Curly kale	302.0 d ± 8.15	302.0 d	61.9 b ± 2.96	80.6 b	59.1 b ± 6.07	83.9 b	153.5 c ± 2.38	208.7 c	16.7 a ± 1.04	24.9 a	51.1 b ± 2.14	69.5 b	48.3 b ± 1.92	72.4 b
Broccoli	277.7 d ± 4.53	277.7 e	94.3 b ± 2.01	111.3 c	115.1 c ± 2.33	147.3 d	89.5 b ± 3.67	104.8 c	52.1 a ± 1.30	59.9 b	110.7 d ± 3.30	23.6 a	111.9 d ± 6.27	23.9 a
White cauliflower	171.2 e ± 3.02	171.2 e	47.6 b ± 4.58	49.9 b	108.9 c ± 6.43	116.5 c	134.7 d ± 2.46	141.4 d	36.7 a ± 1.31	37.4 a	36.4 a ± 3.53	37.9 a	27.5 a ± 2.64	28.0 a
Green cauliflower	61.0 c ± 5.94	61.0 c	37.9 b ± 2.97	39.9 b	55.7 c ± 4.26	59.6 c	31.8 b ± 1.14	33.4 b	76.5 d ± 2.23	78.0 d	10.2 a ± 0.37	10.7 a	7.42 a ± 2.42	7.45 a
Brussels sprouts	37.6 e ± ± 3.86	37.6 e	18.1 b ± 1.80	19.0 b	6.78 a ± 2.66	7.86 a	28.7 d ± 3.89	29.9 d	22.7 c ± 3.54	24.5 c	22.7 c ± 0.64	23.6 c	22.2 c ± 1.57	23.9 c

Differences between values signed this same letters are non-significant.
[a] See Section 3.
[b] SD: standard deviation.