

ESTIMATED DIETARY INTAKES OF NITRATES IN VEGETARIANS COMPARED TO A TRADITIONAL DIET IN POLAND AND ACCEPTABLE DAILY INTAKES: IS THERE A RISK?

Marta Mitek¹, Anna Anyżewska², Agata Wawrzyniak²

¹ Division of Fruit and Vegetable Technology, Department of Food Technology, Faculty of Food Sciences, Warsaw University of Life Sciences, Warsaw, Poland

² Chair of Nutritional Assessment, Department of Human Nutrition, Faculty of Human Nutrition and Consumer Sciences, Warsaw University of Life Sciences, Warsaw, Poland

ABSTRACT

Background. Vegetarian diets, by definition, are rich in vegetables and so may have high levels of nitrates, that can elicit both positive or negative effects on the human body. Exposure to nitrates can thus be potentially higher for this population group.

Objective. To estimate dietary nitrates intakes in Polish vegetarians and compare these with the Polish average.

Material and methods. A sample of 86 vegetarians were surveyed via a questionnaire to determine nitrate intake for those adopting a vegetarian diet. Nitrate intakes for the average Pole were obtained from the Central Statistical Office.

Results. The domestic intake of nitrate, per average person, during 2000-2009, ranged from 115.5 to 133.7 mg NaNO₃ with a mean of 125 mg NaNO₃ of which 35.4% constituted the Acceptable Daily Intake (ADI). For vegetarians, the corresponding levels ranged from 37.3 to 2054.3 mg NaNO₃ with a mean intake of 340.1 mg NaNO₃ of which 95.8% represented the ADI. This was almost twice more than values obtained from calculating nitrate intakes of a typical 7-day vegetarian menu; 104.5 to 277.6 mg NaNO₃ with a mean 175.9 mg NaNO₃ with the 49.1% making up the ADI.

Conclusions. The nitrate intakes in the tested vegetarians were 140 to 270% higher than ones for the average Pole, however in both cases the ADI was not exceeded. Nevertheless, the higher intake of nitrates so observed in vegetarians can be hazardous to some from this population group.

Key words: nitrates, vegetarian diet, intake

STRESZCZENIE

Wprowadzenie. Dieta wegetariańska, bogata w warzywa a przez to w azotany (V) może mieć korzystny jak i niepożądany wpływ na organizm człowieka. Wegetarianie narażeni są na większe pobranie azotanów (V) z diety ze względu na większy udział w niej warzyw.

Cel. Celem badań było oszacowanie pobrania azotanów (V) przez wegetarian oraz porównanie z pobraniem tych związków przez statystycznego Polaka.

Material i metody. Oszacowanie pobrania azotanów (V) przez wegetarian przeprowadzono metodą ankietową wśród 86 wegetarian oraz na podstawie jadłospisu wegetariańskiego. Oszacowania pobrania tych związków przez statystycznego Polaka dokonano na podstawie danych o spożyciu Głównego Urzędu Statystycznego (GUS).

Wyniki. Pobranie azotanów (V) w gospodarstwach domowych w Polsce w latach 2000-2009 wynosiło od 115,8 mg NaNO₃/os do 133,7 mg NaNO₃/d/os. Średnie pobranie tych związków wynosiło 125,5 mg NaNO₃/d/os co stanowiło 35,4% akceptowanego dziennego pobrania (ADI). Wielkość dziennego pobrania azotanów (V) wśród ankietowanych wegetarian wynosiła od 37,2 mg NaNO₃/os do 2054,3 mg NaNO₃/os. Średnie pobranie tych związków wynosiło 340,1 mg NaNO₃/d/os (95,8% ADI) i było prawie dwukrotnie wyższe niż pobranie tych związków obliczone na podstawie 7-dniowego jadłospisu wegetariańskiego od 104,5 mg NaNO₃/os do 277,6 mg NaNO₃/os, wynoszące średnio 175,9 mg NaNO₃/d/os (49,5% ADI).

Corresponding author: Anna Anyżewska, Chair of Nutritional Assessment, Department of Human Nutrition, Faculty of Human Nutrition and Consumer Sciences, Warsaw University of Life Sciences, Nowoursynowska street 159c, 02-776 Warsaw, Poland, phone +48 22 59 37 122, e-mail: anna_anyzewska@sggw.pl

Wnioski. Średnie pobranie azotanów (V) przez vegetarian stanowiło od 140% do 270% wielkości pobrania tych związków z tradycyjną dietą przez statystycznego Polaka. Akceptowane dzienne pobranie tych związków nie zostało przekroczone zarówno przez vegetarian jak w gospodarstwach domowych. Większe pobranie azotanów (V) przez vegetarian w wyniku większego spożycia warzyw może stanowić zagrożenia dla zdrowia niektórych vegetarian.

Słowa kluczowe: azotany (V), dieta wegetariańska, pobranie

INTRODUCTION

Despite being widely known for many years, the vegetarian diet still breeds controversy. Its advantages are well recognised, however various inherent imbalances may pose a health threat to vegetarians. A diet rich in vegetables, which thereby includes nitrates, may lead to either beneficial or harmful effects on health; some important examples of the latter are methaemoglobinaemia, thyroid dysfunction or the formation of N-nitrosamines [4, 12, 14]. It is also common knowledge that, because of its high content in vegetables, nitrate consumption is higher in vegetarians as compared to the average Pole. Thus, because of the potential health threats posed by excess nitrate consumption, this study aims to determine its intake in a population group vulnerable to high exposure ie. vegetarians, and compare these results with average intakes from the general population.

MATERIAL AND METHODS

The Central Statistical Office in Poland (GUS) provided data for vegetable consumption by the average Pole during 2000-2009 which, together with National data on nitrate contents in selected foodstuffs from scientific publications, served to provide estimates for dietary nitrate intake. Estimations of nitrate intake in vegetarians were made from a typical vegetarian diet [3]. During the winter of 2011, an electronic survey was performed on 86 vegetarians (70 females, 16 males), who had participated in various forums dedicated to vegetarians. Lacto-ovo-vegetarians constituted the largest group (48%), followed by vegans (23%), then lacto-vegetarians (17%) and semi-vegetarians (12%). Most subjects were aged 18-29 years (58%), followed by 26% aged 30-50 years, 9% below 18 years and 7% over 50 years. Over one third declared not having eaten meat over 10 years, 26% from 6 to 10 years and 22% from 2 to 5 years; the rest (17%) less than 2 years. Subjects declared how often and how large the amounts were that they consumed of 29 selected foodstuffs. These foodstuffs, predominantly vegetables, contained either high or lower nitrate levels, which in all cases constituted a major dietary source of nitrates through having such inherently high levels of consumption in vegetarians.

The study took no account of nitrate losses during foodstuff production/manufacture and the daily intakes obtained were related to Acceptable Daily Intakes (ADI) values established by the Committee of Experts from FAO/WHO at the Department of Food Supplements (JEFCA). These were taken as being 0 - 3.7 mg NO₃ / kg body mass (equivalent to 0 - 5.07 mg NaNO₃ / kg body mass) [5], assuming a body mass of 70 kg.

Statistical analyses were performed on the Statistica ver. 10 programme. The *Shapiro-Wilk* test for normality was used which then required the non-parametric *Kruskal-Wallis* test to be used for assessing the significance of differences between genders, age, vegetarians or no, durations of being vegetarian and levels of nitrate intake. The critical value for significance was taken as $p < 0.05$.

RESULTS

The mean nitrate intake of the average Pole, during 2000-2009, was 125.5 mg NaNO₃ per day per individual, constituting 35.4% of the ADI (Table 1). Vegetables and their derived products/preserves accounted for 89.3% of the nitrate intake; the highest levels were seen in potatoes (24%) and beetroots (14%), followed by cabbages (9%), carrots (4%), tomatoes (2%) and cucumbers (2%) (Figure 1). The remaining 45% of the daily nitrate intake originated from various other produce; lettuce, green leafed vegetables, legumes, cauliflower types, pumpkins, peppers, kohlrabi (German turnip), courgettes, green beans, sweet corn, onions, mushrooms as well as root and tuber vegetables and vegetable derived products/preserves.

Table 1 Daily nitrate intake for vegetarians and the average Pole [mg NaNO₃/person] – estimated from literature data

Study group	Mean value (% ADI)	Maximum	Median
Average Pole	125.5 (35.4% ADI)	133.7	127.9
Vegetarians (vegetarian menu)	175.9 (49.5% ADI)	277.6	196.9

The nitrate intake according to a typical 7-day vegetarian menu [3] was estimated to range between 104.5 to 277.6 mg daily/person, with a mean of 175.9 mg daily/person, making up 49.5% of the ADI (Table 1).

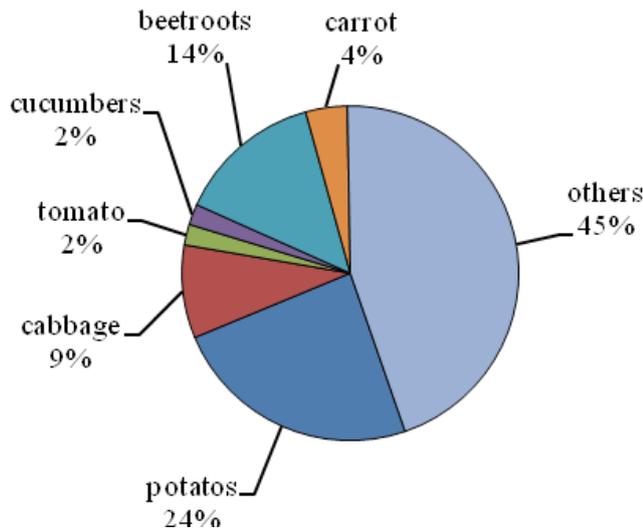


Figure 1. Contribution of vegetables in supply of nitrates in households in years 2000-2009

Vegetables accounted for 86% of this nitrate intake of which 39% originated from spinach, next cauliflower (13%) and various cabbages (11%), such as brussel sprouts, peking and red cabbage; the remaining vegetables were below 10% (Figure 2).

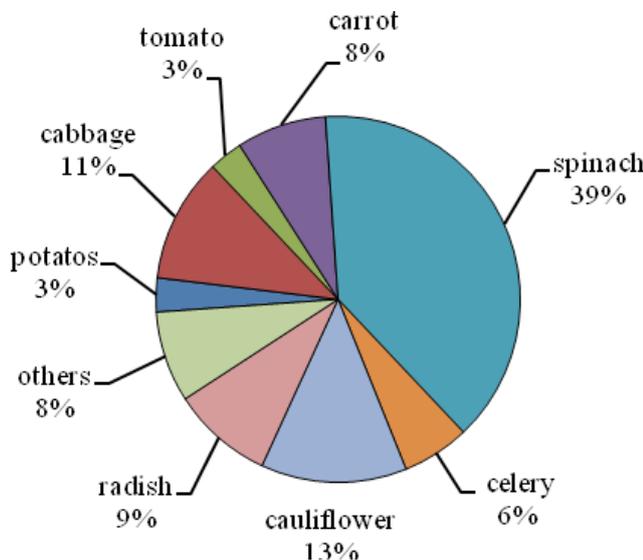


Figure 2. Contribution of vegetables in supply of nitrates from vegetarian diet (vegetarian menu)

The daily intake of nitrates in the tested group of vegetarians varied greatly from 37.2 to 2054.3 mg NaNO₃ per subject, with a mean of 340.1 mg NaNO₃ per subject which represented 95.8% of the ADI. In this group 24 (28%) out of the 86 tested exceeded the ADI. Vegetables accounted for 91% of the nitrate intake. Vegetables having the highest nitrate levels were found to be; radishes (15%), carrots (14%), beetroots (13%) and various cabbages (12%). The least nitrates

were found in tomatoes (2%), potatoes (4%) and leeks (4%) (Figure 3).

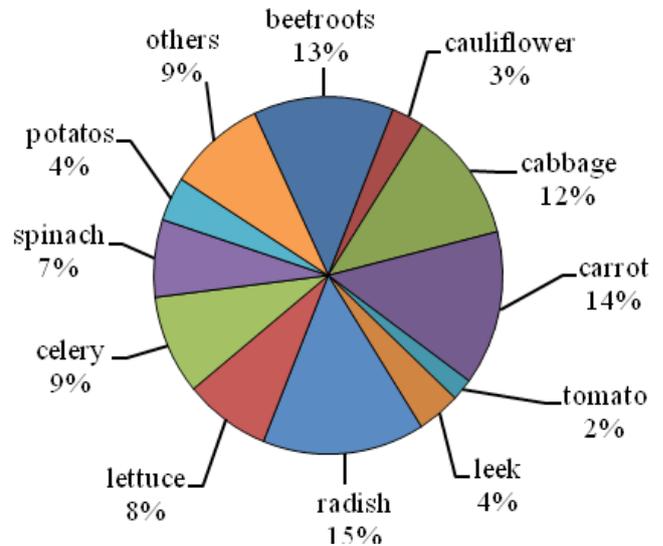


Figure 3. Contribution of vegetables in supply of nitrates from vegetarian diet (questionnaire)

In females of this test group, the mean daily nitrate intake of 361.1 mg NaNO₃ per person which was over 1.5 times greater than in males (233.8 mg NaNO₃ per person). This could be accounted for by a 50% higher daily consumption of vegetables in females compared to males; respectively 598.9 vs. 369.7 g per person. The differences between these nitrate levels were however found to be not significant between genders. Daily nitrate intakes varied according to vegetarian sub-group. The highest intakes were seen in vegans, (455.8 mg NaNO₃/day/person) and the lowest in lacto-ovo-vegetarians (264.7 mg NaNO₃/day/person). The semi-vegetarians demonstrated the highest consumption of vegetables (695.0 g/day/person), whilst the lacto-ovo-vegetarians the least (426.0 g/day/person). The differences in nitrate intakes between lacto-ovo-vegetarians and vegans were statistically significant (Table 2).

Table 2 Daily nitrate intake for vegetarians [mg NaNO₃/person] – survey results

Vegetarians (questionnaire)		Mean value (%ADI)	Maximum	Median
Vegetarians total		340.1 (95.8% ADI)	2054.3	224.0
Study groups	Lacto-ovo-vegetarians	264.7 (74.6% ADI)	1400.7	183.1*
	Lacto-vegetarians	382.1 (107.6% ADI)	1355.0	279.4
	Semi-vegetarianis	355.3 (100.1% ADI)	885.9	219.3
	Vegans	455.8 (128.4% ADI)	2054.3	342.0*

* statistically significant difference

Subjects aged 30-50 years demonstrated the lowest daily nitrate intakes (278.4 mg NaNO₃ per person) compared to the highest seen in those aged over 50 years (454.9 mg NaNO₃ per person). The latter group consumed daily a mean of 797.9 g of vegetables per person representing a 1.8 fold greater amount than those aged 30-50 years. Differences in nitrate intakes between age groups were however not significant. Variations so observed in the mean nitrate intakes reflect that subjects were vegetarian for different lengths of time; the longer this was, then the lower the nitrate intakes tended to be although this was not statistically significant.

DISCUSSION

Absorption and accumulation of nitrates in vegetables is known to be high, thus constituting the main dietary source of these compounds in consumers [14, 15]. Factors affecting the levels so found are; vegetable type and species, environmental conditions, cultivation methods, soil type as well as the conditions and duration of produce storage [2, 10] or food processing [6, 8, 10].

Nitrate intake levels from foodstuffs varies according to different regions of the world, which is not only governed by the amounts contained within, but also on dietary and nutritional customs, including the proportion that vegetables make up of a given daily diet. Because vegetables inherently make up the principal part of a vegetarian diet, exposure to nitrates is high for this group and is estimated to be 3 times greater compared to non-vegetarians eating traditional diets [4, 12]. Indeed, this study demonstrated a 2.7 fold higher nitrate intake in test subjects than the average Pole. However, nitrate intake obtained from adopting the 7-day vegetarian menu was nearly twice less compared to the test group of vegetarians.

The bioavailability of nitrates in vegetables rich in these compounds is 100% for cooked spinach, raw lettuce and cooked beetroot [13]. Nitrates are significantly less toxic than nitrites, however physiological reduction of nitrates to nitrites in the human body can provoke methaemoglobinaemia [12]. In addition nitrites can react with primary, secondary or tertiary amines as well as amino-acids, amides, indole-amines and phenylamines to form nitrosamines, the majority of which endogenously arise in the stomach. In healthy persons, the stomach pH is around 1 - 3 which limits the reducing bacteria from converting nitrates to nitrites. In cases of achlorohydra (ie. lack of gastric hydrochloric acid) nitrates can be then converted to nitrites from which in turn formation of nitrosamines occur; these being well recognised carcinogens. For this reason the most vulnerable groups, in this respect, are those where the

stomach pH is >4 such as in children and the elderly [4, 11].

Nevertheless, ever increasing and recent studies, have demonstrated the beneficial human health effects of nitrates. Drinking 500 ml of beetroot juice causes a significant decreases in systolic and diastolic blood pressure lasting for 3 hours [16]. Platelet aggregation is also inhibited with dietary sodium nitrate supplementation (0.5 - 2 mmol) or by drinking the beetroot juice [9, 16]; improvements by these means are also observed in muscular stamina.

CONCLUSIONS

1. Average nitrate intakes in vegetarians were respectively 140% and 270% higher, resulting from adopting a typical vegetarian diet or by the test subjects compared to those of the average Pole.
2. The nitrate ADI value was not exceeded by both vegetarians or those from average households; the respective ranges of the ADI were 49.9-95.8% and 35.4%. The higher dietary intake of nitrates in some vegetarians may pose a threat to health.

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