Nitrate in vegetables – balancing risks and benefits

Scientific opinion of the CONTAM Panel adopted 2008

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Overview

Introduction

Occurrence and exposure

Hazard identification and characterisation

Risk characterisation

Benefit identification and characterisation

Risk benefit characterisation

Conclusions

Recommendations
Introduction
Consumers need clear advice
On the one hand.......

Vegetables are part of a healthy diet.
On the other hand......

Nitrate via nitrite can lead to potential adverse health outcomes

Gastric Carcinoma

Blue Baby Syndrome

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EFSA was asked by EC

“..provide a scientific risk assessment for the longer term strategy for managing the risk from nitrate in vegetables.”

“..to assess the risks to consumers from nitrate in vegetables. The assessment should take into account the amounts of nitrate found in vegetables as consumed and any relevant considerations on the possible balance between risks and beneficial health effects”.
<table>
<thead>
<tr>
<th>Foodstuff</th>
<th>Maximum levels (mg nitrate/kg)</th>
</tr>
</thead>
</table>
| Fresh spinach                                                            | Harvested 1 October to 31 March: 3000  
Harvested 1 April to 30 September: 2500                                                   |
| Preserved, deep-frozen or frozen spinach                                 | 2000                                                                                           |
| Fresh lettuce (protected and open-grown lettuce) excl lettuce l below   | Harvested 1 October to 31 March: 4500  
lettuce grown under cover: 4000  
lettuce grown in the open air: 3500  
Harvested 1 April to 30 September: 2500                                                   |
| Iceberg-type lettuce                                                    | Lettuce grown under cover: 2500  
Lettuce grown in the open air: 2000                                                               |
| Processed cereal-based foods and baby foods for infants & young          | 200                                                                                           |
The four-step paradigm in risk assessment

**Hazard identification**
- Occurrence data
  - EFSA: E.U. Member States, Island, Norway, Switzerland and Liechtenstein

**Food consumption data**
- Concise European Food Consumption Database

**Exposure assessment**
- Deterministic vs. probabilistic approach
  - Adults, subgroups of population (e.g. children, infants, vegetarians, pregnant women etc)

**Hazard characterisation**
- ADME, acute, subchronic & chronic toxicity
- Human studies: genotox, reprotox, immunotox, mode/mechanism of action, dose-response, selection of critical dataset and e.g. NOEAL, mathematical modelling (BMD) including the establishment of a health based guidance value (e.g. ARfD, TDI)

**Risk characterisation**
- Relating exposure estimates to health based guidance value
Occurrence/exposure
Nitrate in our diets

Dietary nitrate exposure - UK

Vegetables and fruit: 52%
Animal-based products: 12%
Other foods: 6%
Beer: 8%
Water: 6%
Conversion of nitrate: 22%

91 mg/person/day

Dietary nitrate exposure - France

Vegetables and fruit: 75%
Animal-based products: 6%
Other foods: 4%
Beer: 1%
Water: 14%
Conversion of nitrate: 1%

141 mg/person/day

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Nitrite in our diets – External sources

Dietary nitrite exposure - UK

Dietary nitrite exposure - France

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Total Nitrite in our diets – External + Internal

Total nitrite exposure - UK
- Vegetables and fruit: 83%
- Animal-based products: 2%
- Other foods: 6%
- Beer: 8%
- Water: 0%
- Conversion of nitrate: 1%

Total nitrite exposure - France
- Vegetables and fruit: 85%
- Animal-based products: 6%
- Other foods: 6%
- Beer: 2%
- Water: 0%
- Conversion of nitrate: 1%

7.3 mg/person/day
11.3 mg/person/day
So how did the CONTAM Panel tackle the assessment of nitrate in vegetables?

- **Analytical data from 20 Member States and Norway from 2000-2007**: 41,415
- **Vegetable varieties (sufficient data)**: 59
- **Vegetable Categories as in (EC 178/2006)**: 9
- **Huge range median nitrate conc.**: 1 – 4,800mg/kg
- **Data below LOD**: <5%
Nitrate levels in vegetable groups

- Brassica vegetables
- Bulb vegetables
- Fruiting vegetables
- Fungi
- Herbs
- Leafy vegetables
- Legumes
- Stem vegetables
- Roots and Tubers

**Median concentration mg/kg**

- Rucola: 241
- Butterhead lettuce: 60
- Lettuce: 83
- Iceberg lettuce: 41
- Spinach: 844
- Water cress: 302
- **Rucola**: 4,800
- **Butterhead lettuce**: 1,978
- **Lettuce**: 915
- **Iceberg lettuce**: 785
- **Spinach**: 12
- **Water cress**: 56

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Influence of season, production system and region on nitrate levels

Nitrate levels in lettuce produced in southern < northern Europe

Production under cover lead to higher nitrate levels
Mitigation factors for nitrate

• Storage time and conditions (ambient, refrigerated, frozen) and food processing (washing, peeling, blanching, boiling) can influence nitrate levels.

• E.g. reduction of nitrate levels by 10-15% when washing leafy vegetables, 30% when peeling potatoes, 16 to 79% when cooking peas, beans, carrots, potatoes, spinach, endives and celery leaves.

Paucity of published data in this area
Vegetable Consumption is very variable in Europe

• No typical consumer

• Estimates of WHO GEMS Food Consumption cluster diets database: mean 372 g

• Data from 11 Member States & Norway: 97.5th percentile 393 g

• WHO recommendation: 400g/person/day fruit and vegetables

• CONTAM selected 400 g/person/day as a conservative figure

ASSUMED ALL CONSUMED AS VEGETABLES

• Tested impact of different “high consumer” scenarios, eg., 771g potatoes/d Ireland and 133g/d leafy vegetables in Spain

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### Exposure scenarios

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Vegetable consumption (g/person/day)</th>
<th>EU overall median nitrate conc. (mg/kg)</th>
<th>Exposure (mg NO$_3$/person/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>400 (mix, except potatoes)</td>
<td>392</td>
<td>157</td>
</tr>
<tr>
<td>S2</td>
<td>771 (potatoes)</td>
<td>106</td>
<td>82</td>
</tr>
<tr>
<td>S3</td>
<td>133 (spinach/lettuce/1/3 rucola 2/3 lettuce)</td>
<td>785/1,338/4,800</td>
<td>104/178/330</td>
</tr>
<tr>
<td>S4</td>
<td>133 (spinach/lettuce)/267 (mix)</td>
<td>785/1,338/392</td>
<td>209/283</td>
</tr>
<tr>
<td>S5</td>
<td>133(spinach/lettuce)/267 (mix)</td>
<td>1,745/2,652/392 Highest regional median nitrate conc.</td>
<td>337/457</td>
</tr>
</tbody>
</table>

Main driver **not** amount of vegetable eaten, but type and nitrate content
Population subgroups

• Children

No accurate data on vegetable consumption, hence 200 g was chosen as a realistic estimate. For a 20 kg child nitrate exposure would be between 2 and 12 mg/kg b.w. per day.

• The CONTAM Panel is currently addressing possible public health risks for infants and young children from the presence of nitrates in leafy vegetables - due to 15 Dec 2010

• Vegetarians

Protein requirements from animal products are substituted by cereals, nuts, pulses (low nitrate content) and not by excessive amounts of vegetables. Vegetarians are not different from S1 scenario (400 g vegetables).
Hazard identification and characterisation
Toxicokinetics

- Nitrate is quickly absorbed from the gastrointestinal tract into the plasma.
- App. 25% of the plasma nitrate is via the salivary glands bioconcentrated app. 10-fold and secreted into the saliva.
- App. 20% of the secreted nitrate is reduced to nitrite.
- Under acidic conditions, nitrate is transformed to NO and other metabolites.
- Most adsorbed nitrate is excreted in the urine.
- Salvage through reabsorption from the kidney together with biliary and salivary recirculation.
• Toxicity of nitrate is low and adverse effects can occur from its metabolic conversion to nitrite.
• Since the last evaluation by JECFA in 2003 no new significant toxicity data have been reported.
  – Nitrate/nitrite is not genotoxic;
  – Nitrate has a low chronic toxicity;
  – Nitrate is not carcinogenic to humans (JECFA, 2003).
Acceptable daily intake (ADI) - nitrate

- Former SCF and JECFA derived an ADI of 3.7 mg/kg b.w. / day (60 kg adult)
- The ADI equates to 222 mg/day for an adult.
- No new data were identified by the CONTAM Panel to revise this ADI.
Risk characterisation
<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Vegetable consumption (g/person/day)</th>
<th>Exposure (mg NO$_3$/person/day *)</th>
<th>% of ADI (mg/day for 60 kg adult)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>400 (mix, except potatoes)</td>
<td>201</td>
<td>91</td>
</tr>
<tr>
<td>S2</td>
<td>771 (potatoes)</td>
<td>126</td>
<td>57</td>
</tr>
<tr>
<td>S3 (A/B/C)</td>
<td>133 (spinach/lettuce/1/3 rucola 2/3 lettuce)</td>
<td>148/222/374</td>
<td>67/100/168</td>
</tr>
<tr>
<td>S4</td>
<td>133 (spinach/lettuce)/267 (mix)</td>
<td>253/327</td>
<td>114/147</td>
</tr>
<tr>
<td>S5</td>
<td>133 (spinach/lettuce)/267 (mix) regional</td>
<td>381/501</td>
<td>172/226</td>
</tr>
</tbody>
</table>

*) inc. background exposure from other sources 44 mg/person/day

Exposure normally below the ADI, but can be exceeded for certain consumers
• S3C: Consumption of 1/3 of leafy vegetables as rucola.

47 g rucola would result in an excursion above the ADI without taking background into consideration.

• S4 and S5: High-level consumer of vegetables and lettuce at 97.5th percentile or at the highest regional level.

Occasional exceedance of the ADI by two-fold will not lead to appreciable health risks.
Benefit identification and characterisation
Whole vegetables v phytochemicals

“Putting two and two together, scientists assumed that these antioxidants were protective and that taking them... in fortified foods should decrease oxidative damage”
What are the Impacts of eating vegetables?

Vegetables are good for your health

400g fruit and vegetables/day recommended by WHO, 2003

Prevention of non-communicable diseases eg

- cardiovascular
- cancer
- obesity
- type 2 diabetes
Risk/benefit characterisation
Balancing risk and benefit

Pros and cons of exposure to nitrate
Pros and cons of eating vegetables

Nitrate ($\text{NO}_3$)

**Risk**
- methHb
- cancer

**Benefit**
- host defence
- nitric oxide

**Vegetable**

**Risk**
- antinutrients
- allergens
- mycotoxins
- contaminants
- pesticide residues

**Benefit**
- health
- macro/micro nutrients
- lifestyle

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Weighing risks and benefits

Overall the estimated exposures to nitrate from vegetables are unlikely to result in appreciable health effects.

The beneficial effects of eating vegetables prevail.
Conclusions & recommendations
Conclusions

• No need to revise the ADI for nitrate.
• Minority of Europeans eat 400g vegetables/day.
• Nitrate reduces during processing & cooking & is low in fruit.
• Thus for the majority, vegetable nitrate intake is below the ADI.
• High level consumers may exceed the ADI two fold. Consumption of 47 g rucola leads to an excursion of the ADI.
Conclusions

• General consensus that a balanced diet high in vegetables and fruit confers significant health benefits (reduction of non-communicable diseases).

• Overall, estimated exposures to nitrate from vegetables are unlikely to result in appreciable health risks. The recognised beneficial effects of consumption of vegetables prevail. Occasionally circumstances (eg. unfavourable production conditions, diets with high rucola) which need to be assessed on a case by case basis.
Recommendation

- Need for research into factors influencing nitrate levels during production, storage and processing.
- Member States should submit individual analytical results on those crops regularly found to contain high nitrate levels.
- Monitoring of dietary habits of vegetables e.g. rucola
- Continue efforts to progress in methodology for risk-benefit analysis of foods.
The opinion of the CONTAM Panel related to nitrate in vegetables (question No. EFSA-Q-2006-071) is available at URL:

ACKNOWLEDGEMENT

Working group members
- Tom Addiscott
- Piet van den Brandt
- Andrew Cockburn (chair)
- Maria-Luisa Fernandez-Cruz
- Per Ola Danerud
- Peter Fuerst
- Gerrit Speijers
- Philippe Verger
- Hans Verhagen

CONTAM Panel members
2006-2009
Σας ευχαριστώ για την προσοχή σας!