

FSIS 74/05

2004 UK MONITORING PROGRAMME FOR NITRATE IN LETTUCE AND SPINACH

Summary

During 2004 the Food Standards Agency carried out a Monitoring Programme for nitrate in lettuce and spinach. The results of this monitoring programme are reported here. Two hundred samples of UK lettuces and spinach were sampled from eight growing regions across the UK. The samples were collected by ADAS Ltd. Analyses for nitrate were carried out by Direct Laboratories.

Maximum permitted levels of nitrate in lettuce and spinach are set by EU legislation. This legislation allows an optional transitional period (termed a “derogation”) during which the limits do not apply. Several Member States including the UK applied this derogation, which ended on January 1st 2005 for lettuce. An extension of this derogation is currently under consideration within the EU. The derogation for spinach is currently being reviewed.

During 2004, 118 samples of UK-grown lettuce (excluding iceberg) were collected and analysed. Twelve of these samples (10 percent) would be above the limits if they applied in the UK. Forty-one samples of iceberg lettuce were analysed, none of which exceeded the limits. Forty samples of spinach were analysed and five (13 percent) would be above the limits if they applied in the UK. One sample of rocket was also analysed. No sources of winter spinach were found and no frozen or preserved spinach of UK origin were located in retail outlets.

Estimations of nitrate intake show that the highest nitrate levels in lettuce and spinach found during the UK Monitoring Programme are unlikely to cause even high-level (97.5th percentile) consumers of lettuce or of spinach to exceed the Acceptable Daily Intake (ADI) as set by the Scientific Committee for Food, taking into account all sources of nitrate in the

diet. There is therefore no concern for consumer health due to levels of nitrate in UK-grown lettuce or spinach.

Background

Nitrate in food

Nitrate occurs naturally in most plants and vegetables. The concentration of nitrate in plants is affected by species, fertiliser use, variety and growing conditions, of which, light has the greatest influence. Plants remove nitrogen from the soil in the form of nitrate and convert it into proteins during photosynthesis. Poor light conditions (such as those observed in the UK in winter or during cloudy spells in summer) can result in a lower rate of photosynthesis, creating an accumulation of nitrate in the plant tissues.

Vegetables supply between 70 and 90 percent of nitrate intake in the diet.¹ Green leafy vegetables, such as lettuce and spinach, generally contain higher levels of nitrate than other foods. Studies of nitrate in food have demonstrated the possibility of both beneficial and detrimental health effects.²⁻⁶ Excessive nitrate intake can have harmful effects including causing a type of anaemia. However, recent research has suggested that dietary nitrate may have beneficial effects based on the anti-microbial actions of nitric oxide (NO) in the gut.⁴⁻⁶ Although, in 1999 The UK Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (COT) stated that these hypotheses were speculative and were not supported by the data, and that further studies were needed.

The available data on nitrate have been considered on a number of occasions by independent expert committees including the EC Scientific Committee on Food (SCF). In 1995 the SCF considered the safety of nitrate and recommended an Acceptable Daily Intake (ADI) of 3.7 milligrams per kilogram bodyweight per day (equivalent to 220 milligrams per day for a 60 kilogram adult).¹ This is a level of intake that would not be expected to result in any risk to health even if consumed every day over a lifetime. Additionally, the safety of nitrate has been considered by the Joint FAO/WHO Expert Committee on Food Additives (JECFA), most recently in 2002. JECFA also recommended an ADI of 3.7 milligrams per kilogram bodyweight per day.

European Commission legislation on nitrate in lettuce and spinach

The Contaminants in Food (England) Regulations 2003 (SI [2003] 1478) implemented European Commission Regulations 466/2001 and 563/2002 setting limits for nitrate in

lettuce and spinach.^{7,8,9} The limits vary according to season; higher nitrate levels are permitted in crops grown in winter compared with those grown in summer. For lettuce, different limits also apply to glasshouse-grown and outdoor crops. The current limits for nitrate in lettuce and spinach are summarised in Table 1. For details on Commission Regulation (EC) No 563/2002 refer to the European Commission website: http://europa.eu.int/eur-lex/en/archive/2002/l_08620020403en.html.⁹

Derogation (Exemption from the Regulation)

EC Regulation 466/2001 (as amended by Regulation 563/2002) allowed for an optional derogation from the limits for nitrate in lettuce and spinach grown and sold in individual Member States for a transitional period, providing that levels of nitrate present are acceptable on public health grounds. Member States applying the derogation are obliged to apply a code of Good Agricultural Practice (GAP) to ensure that levels of nitrate in lettuce and spinach are as low as possible.

Several Member States including the UK applied this derogation. The code of GAP was formulated by the National Farmers Union in association with the Food Standards Agency. The code is implemented through a product assurance scheme operated by Assured Produce. For more details on this scheme please refer to the Assured Produce Scheme website (<http://www.assuredproduce.co.uk/>). The derogation does not apply to lettuce and spinach imported into the UK from Member States and third countries and the limits apply to these products.

The derogation for lettuce ceased on 1 January 2005. Many Member States, including the UK, have submitted data to the European Commission demonstrating that their respective industries were unable to comply with the new limits, possibly due to lower light conditions in some parts of Northern Europe. The Commission has accepted the need for action. Extension of the derogations is currently under consideration in the EU. Stakeholders are kept updated on developments via regular letters to interested parties.

UK Monitoring Programme for Nitrate in Lettuce and Spinach

EC Regulation 563/2002 stipulates that all Member States carry out monitoring for nitrate in lettuce and spinach and report the results annually to the European Commission. The UK has carried out a Monitoring Programme for Nitrate in Lettuce since May 1996. The results from previous surveys are reported in MAFF Food Surveillance Information Sheets

121,¹⁰ 154,¹¹ 158¹² and Food Standards Agency Food Survey Information Sheets 16/01,¹³ 63/04¹⁴ and 70/05.¹⁵

Methodology

Sampling

Sampling of lettuce and spinach for the 2004 UK Monitoring Programmes was carried out by ADAS in accordance with European Commission guidelines.¹⁶ Once collected, samples were stored below 10 degrees Celsius and transported to the analytical contractor (Direct Laboratories) within 24 hours of harvest or purchase. The samples were then analysed within 3 working days of their receipt.

The sampling was designed to be representative of the major lettuce and spinach growing areas of the UK whilst ensuring that all relevant categories of produce were covered and samples were taken throughout the whole of the 2004 calendar year. Samples were taken from South East England, South West England, East Anglia, the Midlands, North East England, North West England, Scotland and Northern Ireland. The sampling ensured that seasonal growing trends were reflected. Samples of iceberg lettuce (outdoor), non-iceberg lettuce (glasshouse and outdoor) and fresh spinach were taken. No sources of frozen/canned spinach of UK origin were identified and winter spinach was not available.

Analysis

Each sample comprised of 10 heads of lettuce or packets/boxes of spinach, combined and homogenised to produce a representative test sample. All samples were analysed by Direct Laboratories using a method developed during a previous project.¹⁷ This method utilised a hot water extraction followed by HPLC and is described in detail in Food Standards Agency Analytical Bulletin No 16.¹⁸

Sample preparation and analysis was carried out in accordance with Commission Directive 2002/63/EC⁷ and European Commission Guideline Document VI/4800/96.¹⁹ These guidelines and the directive do not specify particular analytical methods, however they do set criteria for sample collection and preparation, and the required precision and analytical performance, including statistics for recovery and precision, for the methods used. Direct Laboratories participated in the nitrate rounds of the Food Analysis Performance Assessment Scheme (FAPAS) and achieved a satisfactory performance.

Measurement Uncertainty

The analytical results reported contain an element of variability known as measurement uncertainty (MU). For any analytical method each result is reported as the best estimate for the sample, qualified by a measurement of uncertainty, for example, x milligrams per kilogram plus or minus y milligrams per kilogram. It is within this range of values that the analyst is 95 percent sure that the true value lies. For the Nitrate Monitoring Programme the calculation of MU was carried out using Direct Laboratories' in-house data and a standard coverage factor of 2, equivalent to a confidence factor of 95 percent. For these analyses a method uncertainty figure of plus or minus 8 percent nitrate was derived for the whole range of results from 141-5720 milligrams per kilogram. The results reported are the best estimate values, corrected for recovery, but do not take into account the measurement uncertainty. Food Standards Agency surveys and monitoring activities are usually reported in this manner since these best estimate values are used to calculate dietary intakes of nitrate and taking into account measurement uncertainty may lead to underestimates of exposure.

Results

In total, 199 samples of lettuce and spinach (and one of rocket) were collected and analysed. As has been previously observed, levels of nitrate for lettuce and spinach were generally higher during winter months (that is October to March) compared to summer.

One hundred and eighteen samples of lettuce (excluding iceberg) were analysed for nitrate. Results ranged from 181 – 2656 milligrams per kilogram for summer outdoor crops, 676 – 4382 milligrams per kilogram for summer indoor crops, 810 – 3100 milligrams per kilogram for winter outdoor crops and 1945 – 5720 milligrams per kilogram for winter indoor crops (Tables 2 and 3). Although the mean level of nitrate in the lettuce samples collected in 2004 appeared to be only slightly higher than those for the 2003 Monitoring Programme (Table 6), the levels found in individual samples were found to fall within a greater range.¹⁵ Therefore, more samples collected in 2004 (10 percent) would have been over the maximum permitted levels (had they applied in the UK) than for 2003 (2 percent).

Forty-one samples of iceberg were analysed, with results ranging from 188 – 1939 milligrams per kilogram for crops grown outdoors (Table 4). No indoor crops were sampled. Levels of nitrate in this crop were low, and no samples would have exceeded the

regulatory limits. The mean level for iceberg remained similar between 2003 and 2004, and for both years no samples exceeded the limit.

Forty samples of spinach were analysed for nitrate. Results ranged from 141 – 3209 milligrams per kilogram for summer crops (Table 5). Five of the samples collected and analysed (13 percent) would have been above the regulatory limit if it were applied in the UK, showing a decrease, from 36 percent in the 2003 Monitoring Programme. The mean nitrate concentration appeared to drop slightly compared to the previous year.

No sources of winter spinach were identified for collection. Likewise, no frozen or preserved spinach of UK origin was located in retail outlets. One sample of rocket, grown outdoors in summer, was also collected and analysed. There are currently no limits for nitrate in rocket, although the result of 1311 milligrams per kilogram is far below the maximum level for nitrate in lettuce.

The results illustrate the variability observed in nitrate levels in lettuce and spinach from year to year. It is possible that this variation is caused chiefly by the cloudy conditions experienced in the summer of 2004 compared with brighter conditions observed in summer 2003. Lower light levels have been observed to reduce transpiration in lettuce plants, leading to an accumulation of nitrate in the leaves.

Dietary exposure estimates

Estimates of dietary exposures to nitrate were calculated for adults, toddlers and school children who eat average amounts of lettuce, spinach and other foods containing these plants (mean consumers) and for those who eat significantly more than average (high level or 97.5th percentile consumers).

Mean and high level intakes of nitrate in lettuce and spinach were calculated for the 2004 crops for adults, toddlers and school children. The calculations included contributions from green vegetables (including lettuce and spinach) and from canned vegetables (including spinach) as well as other foods from the rest of the diet such as potatoes and cured meat products. Estimates of the intake from water and beer were also included. The estimates indicate that intake of nitrate from lettuce and spinach contributes a significant proportion to the total dietary intake of nitrate in most individuals.

Estimates of intake were calculated using the Food Standard Agency's INTAKE computer programme, which combined food consumption by adults,²⁰ young persons (4-18 years),²¹ and toddlers²² with the level of nitrate observed in foods in the diet. The National Diet and Nutrition Survey provided data on consumption. Data on nitrate levels in lettuce and spinach were obtained from the 2004 Monitoring Programme. A recipe database provided indications of the amount of lettuce and spinach in processed foods as an ingredient. The mean intake of nitrate from the rest of the diet (based on the 1997 Total Diet Study²³) was calculated for comparative purposes. These estimates were then compared with the ADI for nitrate, in order to assess whether nitrate exposure through lettuce and spinach consumption poses a risk to consumers.

Estimated dietary exposures to nitrate for mean and high level consumers of lettuce and spinach for all age groups were below the ADI for nitrate of 3.7 milligrams per kilogram bodyweight, even when taking into account nitrate intake from the rest of the diet. Thus, the highest nitrate levels observed in 2004 are unlikely to lead to high-level consumers of lettuce or spinach to exceed the ADI. This means that there is no concern for human health due to the nitrate content of lettuce or spinach in the UK reported here. There are well-established health benefits from eating fresh fruit and vegetables such as lettuce and spinach, and their consumption as part of a healthy balanced diet is encouraged.

Agency Action

The levels of nitrate observed during the monitoring were generally low. The Agency contacted all growers in writing and informed them of their results and, where appropriate, advised them to examine their quality assurance procedures. None of the individual samples would have posed a risk to consumer health as estimates of dietary exposure were found to be within the ADI set by the SCF.

Conclusions

Although there were more incidences of individual samples reported over the legal limits (had they applied to the UK), during the 2004 monitoring, the mean concentrations of nitrate in lettuce and spinach were similar to the levels observed in 2003.¹⁵

The data indicate that during 2004, UK lettuce growers experienced greater difficulty in complying with maximum levels set by the Regulation despite application of the Code of GAP. The current situation in the UK is similar to that in some other Member States in that

a certain proportion of results would exceed the limits if they applied in that Member State. This is likely to be due to cloudy conditions experienced during summer 2004, which reduce transpiration in lettuce plants, leading to an accumulation of nitrate in the leaves.

The Agency is continuing to work with the UK industry and the Commission to provide a solution to this situation that will ensure consumer safety and choice while not seriously disadvantaging the UK lettuce industry.

The Agency will continue to monitor levels of nitrate in lettuce and spinach. Sampling and analysis for the 2005 UK Monitoring Programme for nitrate in lettuce and spinach is currently being undertaken by Direct Laboratories and ADAS Ltd.

Further Information

For further information, copies of this information sheet or information from the final report please contact:

Dr Wendy Matthews
Food Standards Agency
Chemical Safety Division
Room 702c, Aviation House
125 Kingsway
WC2B 6NH
Tel: +44 (0) 20 7276 8707
Fax: +44 (0) 20 7276 8717
Email: wendy.matthews@foodstandards.gsi.gov.uk

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Table 1**Summary of maximum levels in European Commission Regulation (EC) No. 563/2002, amending Regulation (EC) No. 466/2001**

| Product | | Maximum level (milligrams nitrate per kilogram) |
|-----------------------------------|--|--|
| Fresh spinach | Harvested 1 November to 31 March | 3000 |
| | Harvested 1 April to 31 October | 2500 |
| Preserved frozen spinach | | 2000 |
| Fresh lettuce (excluding iceberg) | Harvested 1 October to 31 March grown under cover | 4500 |
| | grown in the open air | 4000 |
| | Harvested 1 April to 30 September grown under cover | 3500 |
| | grown in the open air | 2500 |
| Iceberg type | grown under cover | 2500 |
| | grown in the open air | 2000 |

Table 2**Summary of results of nitrate analyses of UK glasshouse lettuce (not iceberg) in 2004**

| Season | Number of samples | Number outside EC Max (if it applied) | EU limit (milligrams per kilogram) | Mean nitrate content (milligrams per kilogram) | Range nitrate content (milligrams per kilogram) |
|----------------------------|-------------------|---------------------------------------|------------------------------------|--|---|
| Summer (Apr-Sep) | 18 | 6 | 3500 | 2999 | 676-4382 |
| Winter (Jan-Mar & Oct-Dec) | 33 | 5 | 4500 | 3617 | 1945-5720 |

Table 3**Summary of results of nitrate analyses of UK outdoor lettuce (not iceberg) in 2004**

| Season | Number of samples | Number outside EC Max (if it applied) | EU limit (milligrams per kilogram) | Mean nitrate content (milligrams per kilogram) | Range nitrate content (milligrams per kilogram) |
|----------------------------|-------------------|---------------------------------------|------------------------------------|--|---|
| Summer (Apr-Sep) | 62 | 1 | 2500 | 1140 | 181-2656 |
| Winter (Jan-Mar & Oct-Dec) | 5 | 0 | 4000 | 1997 | 810-3100 |

Table 4**Summary of results of nitrate analyses of UK iceberg lettuce in 2004**

| Indoor/ Outdoor | Number of samples | No. outside EC Max (if it applied) | EU limit (milligrams per kilogram) | Mean nitrate content (milligrams per kilogram) | Range nitrate content (milligrams per kilogram) |
|--------------------|----------------------|--|--|---|---|
| Indoor | 0 | - | 2500 | - | - |
| Outdoor | 41 | 0 | 2000 | 758 | 188-1939 |

Table 5**Summary of results of nitrate analyses of UK fresh spinach in 2004**

| Season | Number of samples | No. outside EC Max (if it applied) | EU limit (milligrams per kilogram) | Mean nitrate content (milligrams per kilogram) | Range nitrate content (milligrams per kilogram) |
|------------------------------------|----------------------|--|--|---|---|
| Summer (Apr – Oct) | 40 | 5 | 2500 | 1815 | 141-3209 |
| Winter (Jan- Mar & Nov- Dec) | 0 | - | 3000 | - | - |

Table 6**Comparison of percentage of samples exceeding limits in 2003 and 2004 (note: legal limits do not apply to these results due to the derogation)**

| Monitoring programme | Average nitrate concentration (milligrams per kilogram) | | | Number (percentage) samples exceeding limits | | |
|-------------------------|--|--------------------|---------|---|--------------------|-----------------|
| | Lettuce | Iceberg lettuce | Spinach | Lettuce | Iceberg lettuce | Spinach |
| 2003 | 1939 | 795 | 2148 | 3 (2 percent) | 0 (0 percent) | 14 (36 percent) |
| 2004 | 2153 | 758 | 1815 | 12 (10 percent) | 0 (0 percent) | 5 (13 percent) |