Nitrate Surveillance Monitoring Program (Annual Report May 2021 - March 2022)

Area of research interest: Chemical hazards in food and feed
Study duration: 2021-04-01
Project status: Completed
Project code: FS101228
Conducted by: RSK ADAS Ltd.
Date published: 6 December 2022
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Nitrate surveillance: Summary

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Summary

Every Member State is required to monitor and report levels of nitrate in specified foodstuffs as part of the European Commission regulation and the UK also requires this information as part of the collection of data to support the review of retained EU law in the UK and inform the setting of policy around maximum nitrate levels. The requirement to carry out monitoring for nitrate in lettuce, spinach and rocket is being met by the UK Nitrate Surveillance Programme. Results are presented for the period between 1st April 2021 and 31st March 2022.

A total of 202 samples were collected within the sampling period, comprising of 130 lettuce, 9 rocket, 26 spinach samples. A further 37 samples categorised at “Other Green Leafy Vegetables”, which comprised of samples including mustard, mizuna, celery, Pak Choi and cabbage. The lowest average nitrate concentration was recorded in summer-grown iceberg lettuce (935.2 mg/kg), and no iceberg samples exceeded the maximum nitrate concentration. The highest average nitrate concentration was seen in winter grown non-iceberg lettuce grown under protection within the lettuce group (3242.2 mg/kg), and in winter-grown rocket overall (4271.2 mg/kg).

The number of samples exceeding the maximum threshold increased this year to 7 samples – 2 samples of open-air non-iceberg lettuce sampled in the summer, 1 sample of protected non-iceberg lettuce in the summer, and 3 samples of spinach. A further 4 samples were within 10% of the maximum threshold.

Consistent with previous years of this project, a strong correlation was found between nitrate concentration and sampling date, with samples collected later in the season showing greater concentrations, indicating potential interactions between nitrate accumulation and climate – particularly light levels and available soil moisture and the accumulation of nitrate in the soil through subsequent fertiliser applications with successive planting. Furthermore, there was significant interaction between nitrate accumulation, product type and cultivation type, which could be further explored to better identify risk factors associated with nitrate accumulation in leafy vegetables grown in the UK.

Introduction

Nitrates (NO3) are chemicals which are present in plants, soils and water. While background levels of nitrate will be present in the soil, additional nitrate will be applied either as inorganic fertiliser (e.g. calcium ammonium nitrate) or through the breakdown of soil organic material during crop production. Plants will uptake nitrates from the soil for amino acid and protein synthesis, although a level of nitrate will be present in plant material at harvest.

Regulatory Framework

Due to the potential human health risk, the European Commission (EC) introduced maximum residue levels in lettuce, spinach and rocket based on a compromise of individual Member States national levels to ensure continuity of trade. The Contaminants in Food (England) Regulations 2003 implement EC regulations 466/2001 and 1881/2006 setting limits for nitrate concentrations in lettuce and spinach.

A new Commission Regulation (EC) No 1258/2011 came into force in December 2011. This Regulation sets out new, permanent limits in green leafy vegetables; except the limits for rocket which applied specifically from 1 April 2012. It ends the previous temporary derogations which permitted the UK and some other EU countries to exceed maximum limits, without compromising consumer food safety, for fresh lettuce and spinach grown and intended for consumption on their own respective territories.

Nitrate Surveillance

EC regulations allow Member States to communicate results of the monitoring programme to the European Food Safety Authority (EFSA) on a regular basis, rather than the mandatory deadline of June 30 each year. Every Member State is required to monitor and report levels of nitrate as part of a European Commission regulation Whilst the UK is no longer part of the EU, monitoring activities have continued to be carried out by monitoring nitrate levels in lettuce, spinach and rocket by the UK Monitoring Programme (under GB retained law 1258/2011 since January 2021). This has been undertaken since May 1996 and reported in earlier MAFF (now Defra)/FSA Food Surveillance Information Sheets. Monitoring of UK grown lettuce, spinach and rocket is currently being led by RSK ADAS Ltd (ADAS) in partnership with NRM Laboratories.

Study Objectives

The current study was undertaken to assess nitrate levels in domestic produce between May 2020 and March 2021 as part of an ongoing monitoring program. This program was undertaken to ensure a representative spread of sampling (including both geographically and seasonally) to ensure the following objectives were met.

1. To collect a total of 200 domestic samples of fresh produce (principally lettuce, rocket and spinach, but also including ‘other leafy green veg’).

2. To carry out the chemical determination of nitrate concentration in fresh tissue in accordance with the appropriate Directives.
3. To report results to the agency in an electronic format.
4. To ensure the grower has received a copy of the results relating to his/her sample.

Quality Assurance

The study was conducted in compliance with the requirements of the Food Standards Agency, as set out in RRD27, February 2008. Sampling methodology conforms to the European Commission guidelines given in Commission Regulation EC/1882/2006 and with the quality assurance procedures adopted previously for the 2002-2018 surveys.

ADAS has its own in-house Quality Management System (QMS) developed to meet the requirements of externally accredited standards applied to parts of the business. ADAS QMS ensures that all work is controlled by documented plans, project management methodology, and carried out by properly trained staff, using suitable equipment and facilities. Business processes and routine procedures are documented in Standard Operating Procedures (SOPs) authorised by management and subject to periodic review. In-built process improvement ensures that ADAS QMS continues to improve and evolve to cover new areas of activity and to be responsive to the changing needs of customers. Compliance with QMS is monitored through formal audit by the operationally independent Quality Management Group.

Audit schedules are designed to cover all key areas of activity. Study specific audits can also be carried out by prior agreement at contract stage. ISO 9001:2000 - ADAS is registered with Lloyd’s Register Quality Assurance (LRQA) for: ‘Provision of independent research, consultancy and contracting services, focused primarily on environmental management, regional development, agriculture, horticulture and the food supply chain, to Government, levy bodies and private sector companies’.

Chemical analysis carried out by NRM Ltd meets the requirements of the Joint Code of Practice for Quality Assurance in Research, complies with EU retained law Regulation (EC) No 1882/2006.

Nitrate surveillance: Methodology

Sampling Schedule

In April 2021 a sampling schedule was prepared by ADAS and agreed by the Food Standards Agency (FSA). The schedule was developed to ensure that samples were representative of the wider UK production. The schedule ensured that the sampling of fresh produce complied with the guidelines given in EU retained law Regulation EC/1882/2006 and met with the requirement to spread the sampling over representative geographical regions throughout the UK. Whilst the sampling period coincided with the ongoing covid-19 pandemic, the sampling activities were not disrupted.

The sampling schedule covered the period from 20th April 2021 to the 28th March 2022 and involved the collection of lettuce, rocket, spinach and other leafy green vegetables from domestic sources. Geographic representation and seasonal growing trends were maintained and it was left to the discretion of the Sample Officer to ensure that appropriate numbers of samples from within each category were collected from a representative cross section of growers. A total of 202 samples were collected across the lettuce, rocket, spinach and other leafy green vegetable categories (**Table 1**). The range of samples included in the other leafy green vegetable category is given in **Table 2**.

Table 1. Summary figures for nitrate samples taken between 20th April 2021 and 28th March 2022.

Crop Type	Count
Lettuce	130
Rocket	9
Spinach	26
Other green leafy vegetables	37
Total	202

Table 2: Summary figures for nitrate samples taken between 20th April 2021 and 28th March 2022 – numbers of "Other Green Leafy Vegetables"

Crop Type	Count
Chinese leaves	4
Bulls Blood	1
Cannabe	6
Celery	2
Kale	5
Komatsuna	1
Mizuna	4
Multi-leaf salad	1
Mustard	3

Crop Type	Count
Pak Choi	3
Red Batavia	1
Red Chard	4
Red Mizuna	2
Total	37

Sampling Collection

Sampling Strategy

Samples were collected by trained Sample Officers, in accordance with Standard Operating Procedure (SOP) ‘Field sampling and transportation of lettuce and spinach samples for the UK Nitrate Monitoring Programme’ (see Appendix) and EU retained law Regulation EC/1882/2006. Prior agreement was obtained from the grower before a sample was taken. A minimum of 10 heads of lettuce or 1.0 kg of spinach, rocket and other leafy green vegetables was randomly collected from various points within the lot. Where samples were collected from the field or glasshouse the sample points were, as far as possible, evenly distributed across the area by walking a ‘W’ pattern back and forth. Lot size did not exceed 2.0 ha and samples were not taken from the field edges. Plants were not collected from patches within the lot which appeared unrepresentative and material that was obviously damaged or diseased was avoided.

Sample Labelling and Documentation

The sampling schedule assigned a unique identification number to each sample, along with details of the Sample Officer, month of collection and region. All samples were anonymised. A copy of the schedule was sent to each Sample Officer and the laboratory to ensure that all parties were fully informed and prepared. Pre-printed labels were provided by NRM and sent directly to the Sample Officers. Samples were sealed and labelled by the Sampling Officer, immediately following collection. The Project Manager held a master copy of the schedule and tracked sample collection, analysis and reporting of results throughout the year. Crop husbandry details were collected by the Sample Officers to accompany each sample. Details included grower, date and time sample was collected, variety or type, location, lot size and fertiliser input.

Transportation of Samples to the Laboratory

Each sample was carefully placed into a clean polythene bag which was subsequently placed into polystyrene insulated box, provided by NRM. Ice packs were placed in the base of the box, as appropriate, to ensure the sample remained below 10oC during transit. The containers provided were inert and offered adequate protection for samples against water loss, deterioration, contamination, damage, heat and significant changes in nitrate content during transportation to the laboratory. Samples were dispatched to the laboratory to arrive before 10.30am on the day after harvest. Samples from Scotland and Northern Ireland were placed in sealed plastic bags and transported in insulated containers at <10oC, which arrived at the laboratory within two days of harvest.

Sample Preparation in the Laboratory

Samples were checked upon receipt to ensure they met the requirements of EU retained law Regulation 1882/2006. Basic checks were carried out to ensure that the temperature upon arrival was below 10oC and that samples were intact and had not begun to degrade during transportation. Associated documentation was checked against the sample and each sample was assigned a unique NRM laboratory number, which was later reported alongside the unique identification number.

Samples were prepared in accordance with the requirements of EU retained law Regulation 1882/2006 and the quality assurance procedures meet the requirements of the Joint Code of Practice for Quality Assurance in Research and are in Compliance with the provisions of items 1&2 of Annex III to Regulations (No 882/2004. The whole sample was homogenised using a protocol developed by NRM Ltd which has been demonstrated to produce suitably homogenous samples. Four representative sub-samples were taken, (A, B, C and D). Sub-sample A was used immediately for analysis. Sub-sample B was kept refrigerated in case of a requirement for repeat analysis when exceedance occurred. Sub-samples C and D were frozen and will be kept in storage for 12 months following the reporting of results.

Analytical Analysis

Analysis commenced immediately after preparation and initial analysis of all samples was completed within five days of sampling. Analysis was undertaken using a UKAS accredited method which fully meets the requirements of EU retained law Regulation 1882/2006. The method is accredited to BS EN ISO 17025: 2005 and has been since 2000. The method uses an extraction procedure which has been shown to be reliable and robust and involves freezing in liquid nitrogen prior to homogenisation. Detection is based on flow injection colorimetry and is currently used by NRM Ltd for analysis of all commercial samples.

The determination of nitrate-N is based on the formation of a diazo compound between nitrite and sulphanilamide. This compound is then coupled with N-1-Napthylethylenediamine dihydrochloride to produce a red azo dye. The colour is measured at a light wavelength of 540 nm in a spectrophotometer. Nitrate is reduced quantitatively to nitrite by cadmium metal in the form of an open tubular cadmium reactor (OTCR). The nitrate content of the sample was calculated from the analysed nitrate-N value. Nitrite-N was monitored and was quantified if it was present. The measurement of Nitrite was not part of the accredited Nitrate method and was dealt with, when required, outside of the accredited system.

If any value was ? 90% of the maximum Nitrate level (**Table 3**) for a particular product then this triggered a requirement for a repeat extraction and analysis of refrigerated Sample B to confirm the high value. This repeat confirmatory analysis was carried out within two days of the initial analysis and both results were reported on the same day.

Table 3. Maximum permitted level of nitrates in lettuce, spinach and rocket.

Product Type	Cultivation	Harvest Date	Maximum permitted level (NO3 mg/kg)

Fresh spinach	Any	Any	3500
Preserved, deep-frozen or frozen spinach	Any	Any	2000
Fresh lettuce Non-iceberg type	Protected	1st October – 31st March	5000
Fresh lettuce Non-iceberg type	Protected	1st April – 30th September	4000
Fresh lettuce Non-iceberg type	Open Air	1st October – 31st March	4000
Fresh lettuce Non-iceberg type	Open Air	1st April – 30th September	3000
Fresh lettuce Iceberg type	Protected	Any	2500
Fresh lettuce Iceberg type	Open Air	Any	2000
Rocket	Any	1st October – 31st March	7000
Rocket	Any	1st April – 30th September	6000
Other Leaf Green Vegetables	Any	Any	n/a

Quality Control

All quality control (QC) information was recorded on the laboratory worksheets. Routinely an in-house reference material is included with every batch of samples at a frequency of at least one QC sample in every batch of twenty samples. A spiked sample may also be included at the same frequency if required. A reagent blank is prepared with each batch of samples. A mid-range standard is included at the end of each batch to ensure any drift over the run is within acceptable limits (+/- 5%). All QC results are plotted on Shewhart Charts and monitored to ensure they conform to NRM's policy on Quality Control (i.e. precision, accuracy, 9 point bias, ascending or descending trends etc).

In-house reference materials are routinely used. These are prepared in-house from material obtained from growers or retailers. These materials are typical of produce entering the retail chain and therefore contain nitrate levels typical of those encountered in the marketplace. New materials are run alongside existing materials to obtain reference values for the new material.

The value obtained for the reagent blank must be less than 0.2 mg/l NO_3^-N. This equates to 8.9 mg/kg. One QC value at ± 2 standard deviations = Warning. Two consecutive QC values at ± 2 standard deviations = Action. One QC value at ± 3 standard deviations = Action.

A QC Failure Record is generated when an Internal QC falls outside the required criteria. This initiates a documented investigation into the cause of the failure under NRM's Non-Conforming Work policy. This typically results in the retained sample being re-extracted and re-analysed from the start.

New in-house reference materials and standard solutions are crossed over against the current reference material or standard solution prior to use. Documented evidence of this cross-over is retained. Control materials are included in every batch at a frequency of at least one QC sample in every batch of twenty samples (5%). LOQ = 50 mg/kg, LOD = 6 mg/kg, Blanks = generally less than 2 mg/kg. Precision values over the relevant concentration range expressed as relative standard deviations; 4.4% at approx. 2000 mg/kg, 8.9% at approx. 450 mg/kg, 11.3% at approx. 100 mg/kg. IHRM: Currently Spinach, mean = 314 mg/kg, SD = 15.6 mg/kg, RSD = 5%.

Recovery was determined on five batches of triplicate samples spiked at three levels. Approx. 2000 mg/kg average recovery = 98%, range = 94% - 105%, approx. 450 mg/kg average recovery = 102%, range = 85% – 114%, approx. 100 mg/kg average recovery = 104%, range = 80% - 117%. Reporting limit = 50 mg/kg. Recovery: acceptable between 90% and 110%. Measurement uncertainty is estimated using precision and bias data.

Reporting of Results

Analysis commenced immediately after preparation and initial analysis of all samples was completed within five days of sampling. Where nitrate levels exceeded the limits the frozen sub-sample was re-analysed within two days of the initial analysis, in all cases. Results were received by ADAS within five days of sample receipt. Nitrate concentrations are expressed in milligrams of nitrate per kilogram of sample fresh weight (mg/kg).

Communication of Results to FSA

Results were reported to the FSA on a monthly basis. Individual data were reported in an Excel spreadsheet and filters were added to the column headings to enable the FSA to search for and group results, as appropriate. Monthly mean values and running totals of maximum, minimum and mean nitrate levels, grouped according to category, were tabulated (Appendix 1 and Appendix 2).

Communication of Results to Growers and Wholesalers

A template letter was produced by the FSA and forwarded to ADAS for use when reporting results (Appendix 3). When the nitrate level of a sample was within the maximum permitted level, as described in retained law Regulation (EC) No 1881/2006 or Regulation (EC) No 1258/2011 (from 02 December 2011 onwards), ADAS reported the results directly to the grower/wholesaler. A copy of the letter was also sent to the FSA. If the nitrate level in a sample exceeded the maximum permitted limit then, following confirmation of the result by NRM, ADAS informed the responsible person at the Agency before reporting the result to the grower/wholesaler (Appendix

4).

Long term sample storage in case of dispute

Sub-samples ‘C’ and ‘D’ (see above) from each sample have been frozen and will be stored by NRM for a period of 12 months after the reporting of results.

Nitrate surveillance: Results

Sample Overview by Region

A total of 202 domestic samples were collected between April 2021 and March 2022 (**Figure 1**). For England, 9 samples were collected from the North East, 21 samples from the North West, 46 from Central England, 23 samples from the East and East Anglia, 48 from South East England and 18 samples from the South West. 10 samples were collected from Wales, 16 samples from Scotland and 11 samples from Northern Ireland.

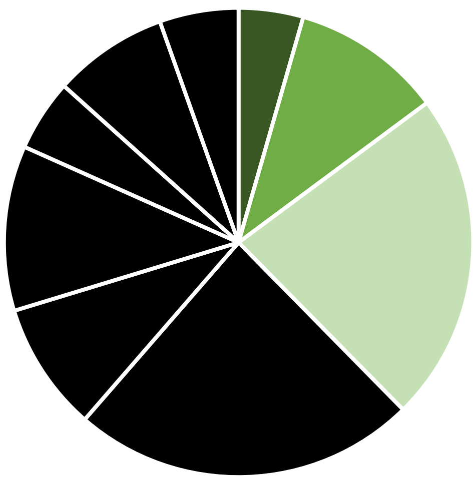

Figure 1. Total counts for samples collected from each region between April 2021 and March 2022.

Summary figures for nitrate concentrations are given in **Table 4**. Four regions had samples with nitrate concentrations below the detectable threshold of 50 mg/kg (North East, Central and South West England, and Northern Ireland). The highest minimum concentration was recorded in Wales (1063.1 mg/kg). Wales also showed the highest average concentration within a region (3515.6 mg/kg) compared with a national average of 2031.9 mg/kg. Two regions were substantially below the national average – the North East (1112.7 mg/kg) and Scotland (1262.6 mg/kg). The highest maximum concentration was recorded in Central England (7046.9 mg/kg), although Wales also recorded significantly high maximum samples (6599.6 mg/kg).

Table 4. Summary nitrate concentration figures by region between April 2021 and March 2022.

Region	Minimum NO3 Content (mg/kg)	Average NO3 Content (mg/kg)	Maximum NO3 Content (mg/kg)
North East	<50	1112.7	4293.6
North West	350	2220.0	4390.1
Central	<50	1970.6	7046.9
South East	51.2	1867.2	4350.1
South West	<50	2156.6	5540.6
East & East Anglia	149	2348.2	5548.6
Scotland	458.4	1262.6	2451.4
N Ireland	<50	2304.5	4620.5
Wales	1063.1	3515.6	6599.6

Values are given in **Table 5** for the number of samples in each region approaching 10% of the maximum threshold, and exceeding the maximum threshold for the corresponding nitrate concentration. Four regions had no samples that were within 10% of the maximum threshold (north east, North West and South West England and Scotland). Only 1 sample exceeded the maximum threshold in central and South East England, East Anglia, and Northern Ireland. Wales had the greatest number of samples which exceeded the maximum thresholds, with 3 of 10 samples exceeding the threshold. Overall, 11 samples were within 10% of the maximum threshold, and 7 samples from a total of 202 exceeded the maximum threshold for the corresponding product type.

Table 5. Regional counts of samples approach 10%, and exceeding, the maximum threshold for corresponding category type.

Region	Total Count	Count within 10% of Maximum	Count Above Maximum Threshold	Percentage of Samples Above Maximum Threshold (%)
North East	9	0	0	0.0
North West	21	0	0	0.0
Central	46	2	1	2.2
South East	48	1	1	2.1
South West	18	0	0	0.0
East & East Anglia	23	2	1	4.3
Scotland	16	0	0	0.0
N Ireland	11	2	1	9.1
Wales	10	4	3	30.0
Total	202	11	7	3.5

Sample Overview by Category

A summary of samples collected by category is given in **Table 6**. The majority of samples were open air non-iceberg lettuce sampled in the summer (49) and protected non-iceberg lettuce sampled in the winter (45). Overall, the majority of samples were of the non-iceberg type (112) with only 18 samples of iceberg-type lettuce collected. Only 9 samples each were collected from open air non-iceberg lettuce sampled in the winter, and protected non-iceberg lettuce sampled in the summer. 26 spinach samples and 9 rocket samples were collected in total.

37 samples categorised as Other Green Leafy Vegetables were collected. This included 6 samples of cabbage, 5 samples of kale alongside Mizuna (4 samples), Red Chard (4), Chinese Leaves (4), Mustard (3), Pak Choi (3), Celery (2), Red Mizuna (2) and single samples of Bulls Blood, Komatsuna Multi-leaf and Red Batavia.

The distribution of samples between category type this season was largely comparable with past seasons. A slight increase in the proportion of non-iceberg type open air lettuce was sampled in 2021-22 compared with 2020-2021 (24.3% vs. 20.9%), largely due to a reduction in the Other Green Leafy Vegetable category (18.3 vs. 23.9%).

Table 6. Summary of sample counts per category, cultivation type and harvest period.

Category	Cultivation	Harvest Period	Count
Lettuce – Non-Iceberg	Open Air	Summer	49
Lettuce – Non-Iceberg	Open Air	Winter	9
Lettuce – Non-Iceberg	Protected	Summer	9
Lettuce – Non-Iceberg	Protected	Winter	45
Lettuce – Iceberg	Open Air	Summer	18
Spinach	n/a	n/a	26
Rocket	n/a	Summer	6
Rocket	n/a	Winter	3
Other Leafy Green Vegetables	n/a	n/a	37

Overview of Nitrate Concentrations

130 lettuce samples were collected, comprising of 18 open air summer iceberg samples, 54 protected non-iceberg types (9 summer, 45 winter) and 58 open air non-iceberg types (49 summer and 9 winter).

Significant variation was seen in nitrate content for lettuce with both season, product type and production method impacting recorded nitrate levels (**Figure 2**, **Table 7**). Levels were relatively low in open air iceberg-type lettuce, with the lowest average nitrate concentration of all category types of 935 mg/kg. Levels were also the most consistent across the season.

Non-iceberg types grown in the open air showed a broader range of nitrate concentrations, ranging from <50 mg/kg to 3250 mg/kg in the summer, and 1037 – 2917 mg/kg in the winter. Average nitrate concentrations in open air non-iceberg types was 1200 mg/kg.

Non-iceberg types grown under protection showed the greatest nitrate concentrations within the salad leaf categories, with the greatest concentration of 5548 mg/kg which was recorded in a winter sample. The average protected non-iceberg type concentration was 3062 mg/kg. Concentrations in protected non-iceberg types were higher in the winter period, ranging from 876 – 5549 mg/kg, compared with 597 – 4620 mg/kg in the summer. Elevated nitrate levels in the winter, particularly in protected samples are likely as a result of lower light levels. Research indicates that lettuce may accumulate nitrate at higher concentrations at lower light levels to aid the plants ability to modulate internal osmotic balance (Blom-Zandstra et al., 1985). Whilst light levels are likely to be a primary driver of this, there is also potential interaction with cultivation system. Protected crops are likely to be exposed to a more consistent external solute concentration (and one which may internally be kept low to drive growth), and with increased rates of transpiration due to supplementary heat provision, which will increase nitrate uptake compared with more inconsistent conditions in open fields.

The accumulation of nitrate to act as an osmoticum will occur to enable plants to maintain favourable internal water volumes and solute concentrations during growth, including buffering environmental changes. A range of osmotica will be used for this including other salts and neutral solutes, and this could be exploited by cultural methods to reduce nitrate accumulation. The increase in nitrate accumulation in low light conditions is likely to counter the reduce availability of sugars due to declines in photosynthesis (Behr et al., 1992). Therefore, increasing light levels through supplementary lighting, increasing the proportion of ammonium used to provide total nitrogen or the harvesting of more mature plants (solute concentrations decline with age) (Burns et al., 2008) may help to reduce levels nitrate accumulation. More innovative approaches could include the application of alternative osmoticum to the roots – a study in which glycine betaine was applied through a fertigation solution led to significant reductions in nitrate accumulation in lettuce (Jokinen et al., 2022). Glycine betaine is already used commercially as a supplementary osmoticum to promote frost resistance in apple when applied as a foliar spray, and so its use could be extended into leafy salad production. These approaches remain experimental, however, and some studies have reported that similar interventions have not had a positive effect (e.g. McCall & Willumsen, 1999) but it would be beneficial to explore the potential positive impacts of these approaches in commercial-scale trials.

No iceberg samples approached 10% of the maximum thresholds. Four non-iceberg lettuce samples exceeded the nitrate threshold – two open air samples collected in the summer, and a winter and summer protected type. Two further winter and summer protected samples were within 10% of the maximum threshold.

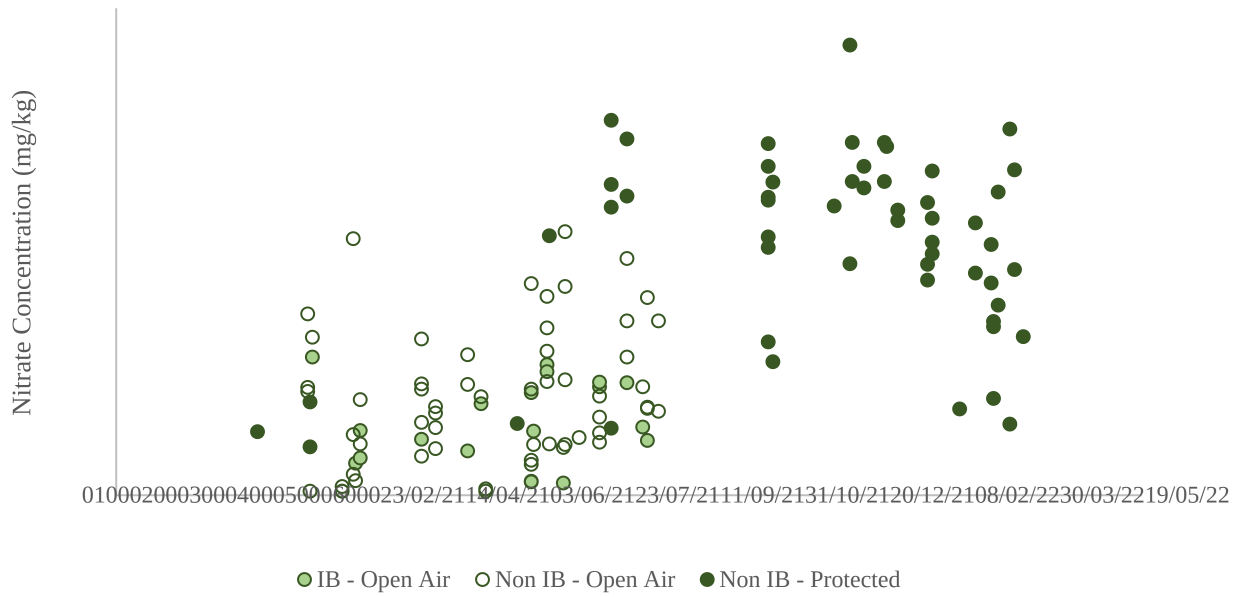

Figure 2. Seasonal nitrate concentrations for iceberg-type (IB) and non-iceberg type (Non-IB) lettuce grown under protection or in open air.

For Other Green Leafy Veg, average nitrate concentrations were 2526 mg/kg, ranging from <50 mg/kg to 7047 mg/kg (**Figure 3**, **Table 7**). Levels were generally lowest in cabbage (508 mg/kg) and highest in Mustard (5329 mg/kg) and Red Mizuna (6701 mg/kg). Levels were lowest in the summer period, increasing in the winter.

Figure 3. Seasonal nitrate concentrations for Other Green Leafy Veg.

For Rocket, average nitrate concentrations across the season were 2642 mg/kg, ranging from 614 – 6600 mg/kg (**Figure 4, Table 7**) although only a limited numbers of samples were collected meaning that it is difficult to compare changes in concentration across the season. One rocket sample was within 10% of the maximum threshold.

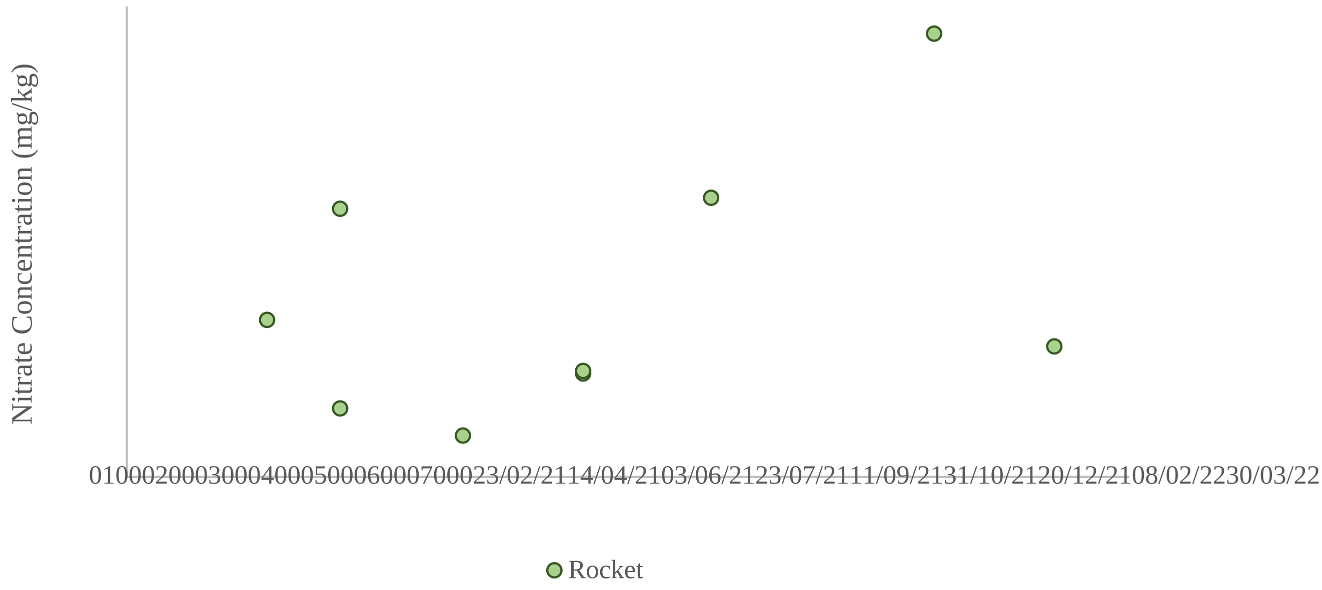

Figure 4. Seasonal nitrate concentrations for Rocket.

For spinach, average nitrate concentrations were 1594 mg/kg, ranging from 93 – 5814 mg/kg across the season (**Figure 5**, **Table 7**). Similar to lettuce, nitrate concentrations were greater in the winter period compared with the summer, and were more variable over this period compared with relatively close values for summer samples.

Three spinach samples exceeded the maximum nitrate threshold, and one further sample came within 10% of the maximum threshold.

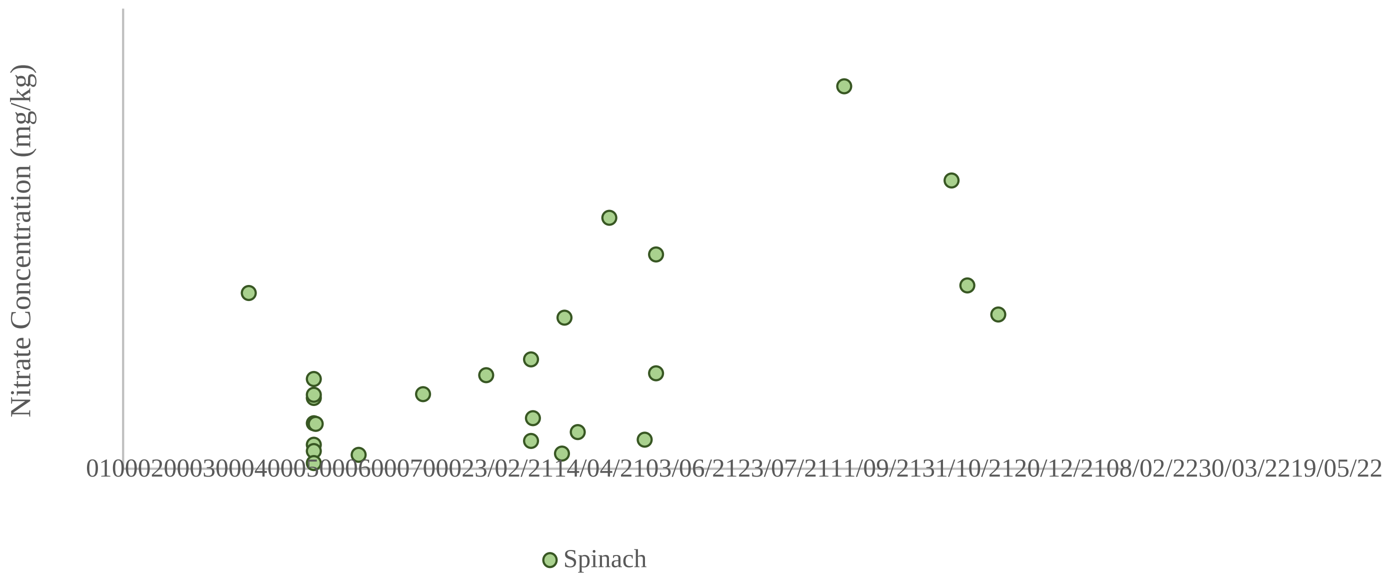

Figure 5. Seasonal nitrate concentrations for Spinach.

When compared against sample sizes, the greatest proportion of samples exceeding the threshold value for nitrate concentration were recorded for Spinach (3 of 26 samples, 11.5%) and protected non-iceberg lettuce sampled in the summer (1 of 9 samples, 11.1%). Summary figures are given in **Table 8**.

Table 7. Summary seasonal nitrate concentrations per category.

Category	Minimum Nitrate Concentration (mg/kg)	Average Nitrate Concentration (mg/kg)	Maximum Nitrate Concentration (mg/kg)
Iceberg	149.0	935.2	1701.3
Non-Iceberg – Open (Summer)	50.0	1096.5	3250.0
Non-Iceberg – Open (Winter)	1037.4	1763.1	2917.8
Non-Iceberg – Open (Season)	50.0	1200.0	3250.0
Non-Iceberg – Protected (Summer)	597.2	2158.9	4620.5
Non-Iceberg – Protected (Winter)	875.7	3242.2	5548.6
Non-Iceberg – Protected (Season)	597.2	3061.7	5548.6
Other Leafy Green Vegetables	>50.0	2526.1	7046.9
Rocket (Summer)	614.1	1846.7	3986.6
Rocket (Winter)	1942.7	4271.2	6599.6
Rocket (Season)	614.1	2642.3	6599.6

Category	Minimum Nitrate Concentration (mg/kg)	Average Nitrate Concentration (mg/kg)	Maximum Nitrate Concentration (mg/kg)
Spinach	92.6	1593.6	5814.3

Table 8. Summary figures for samples approaching 10% of, and exceeding, the maximum nitrate concentrations.

Product Type	Total Count	Count within 10% of Maximum	Count Above Maximum Threshold	Percentage of Samples Above Maximum Threshold (%)
Iceberg	18	0	0	0.0
Non-Iceberg – Open (Summer)	49	2	2	4.1
Non-Iceberg – Open (Winter)	9	0	0	0.0
Non-Ice – Protected (Summer)	9	2	1	11.1
Non-Ice – Protected (Winter)	45	2	1	2.2
Other Leafy Green Vegetables	37	n/a	n/a	n/a
Rocket (Summer)	6	0	0	0.0

Product Type	Total Count	Count within 10% of Maximum	Count AboveMaximum Threshold	Percentage of Samples Above Maximum Threshold (%)
Rocket (Winter)	3	1	0	0.0
Spinach	26	4	3	11.5
Total	202	11	7	5.4

Historical Trends

Average nitrate concentrations in iceberg lettuce grown in the open air in 2021 were consistent with long-term means for this category (935 vs. 931 mg/kg - **Figure 6**). Whilst this is consistent with samples taken in 2017 and 2018, this does not correlate with the 2020 average. However, given the differing sampling strategy in 2020 due to the covid-19 epidemic this year may not be representative of longer term averages.

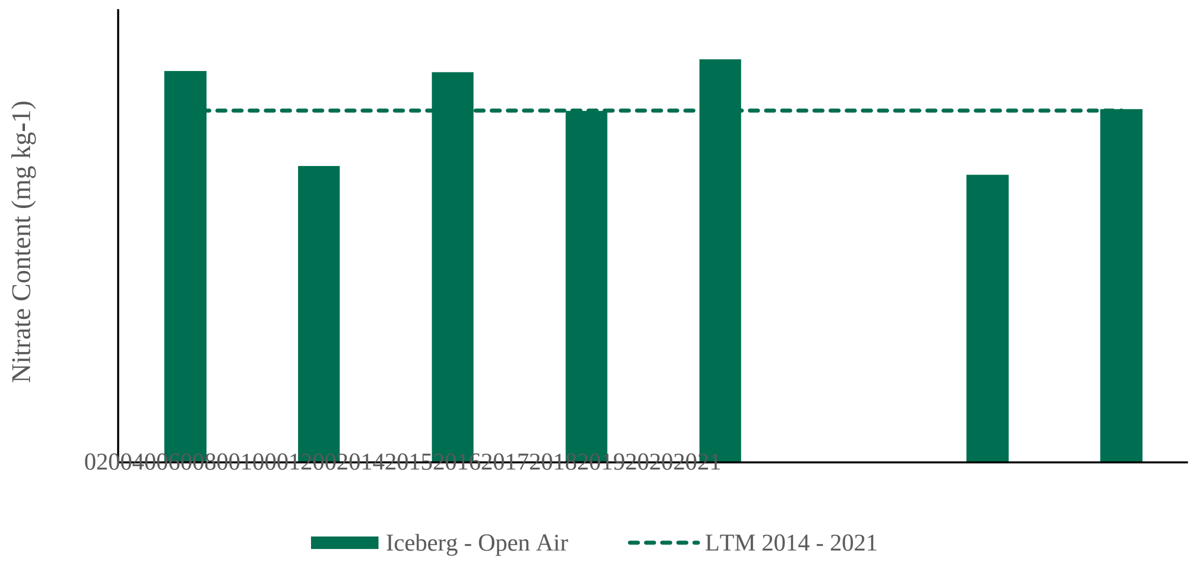

Figure 6. Comparison of annual average nitrate concentrations for outdoor iceberg-type lettuce compared with the long-term mean (LTM).

For non-iceberg types grown in the open air, summer samples in 2021 were significantly below the long term mean (1096 vs. 1245 mg/kg), whilst winter samples were marginally above the long term mean (1763 vs. 1674 mg/kg - **Figure 7**), this is the reverse trend seen from the 2020 although this is likely to have impacted by sampling strategy differences between the two seasons – only three samples were collected in January 2021 . In 2021 the difference between summer and winter samples of open air non-iceberg types was substantial (1096 vs. 1763 mg/kg, an increase of 60.9% between summer and winter), following similar relationships seen between summer and winter samples seen since 2014 except 2016 and 2020.

For protected non-iceberg types, both summer and winter samples were below long term means (**Figure 8**). The summer average in 2021 was 2159 mg/kg compared with a long term mean of 2768 mg/kg. Winter averages were 3382 and 3191 mg/kg in 2021 and 2022 respectively compared with a long term mean of 3500 mg/kg. In 2021 the increase from summer to winter samples was substantial – 1223 mg/kg, an increase of 56.6% - and a continuation of a trend of increasing discrepancies between summer and winter grown samples since 2019. However, given that winter levels have also declined, this reduction is most likely as a result of more consistent growing environments in the winter months leading to increased control of nutrient uptake and management.

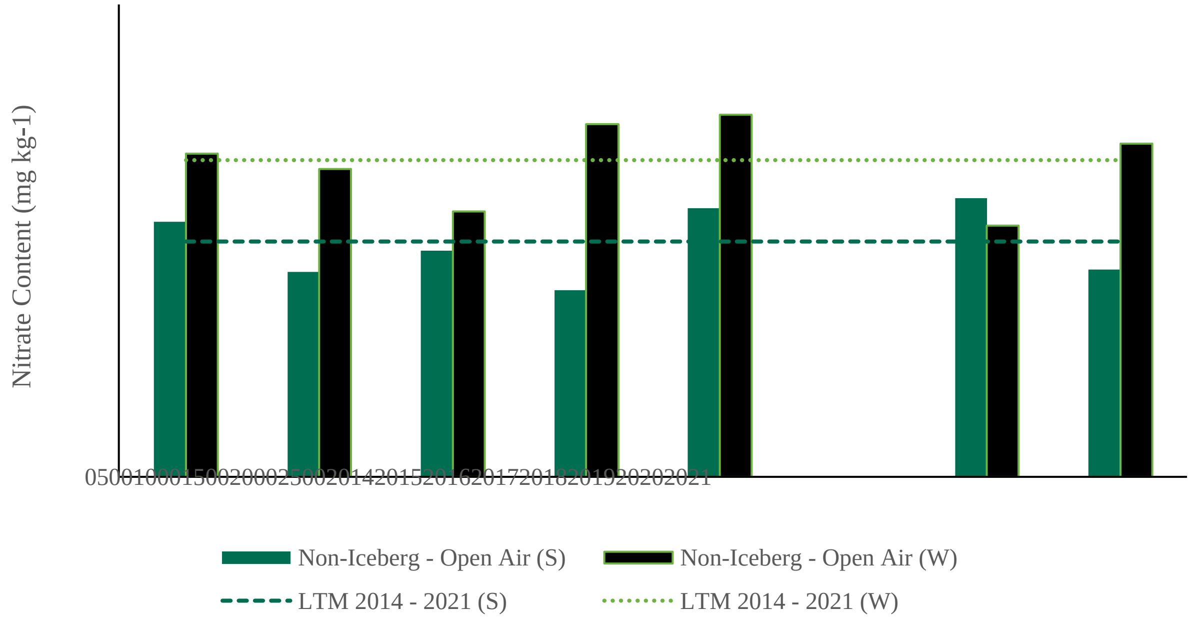

Figure 7. Comparison of annual average nitrate concentrations for outdoor non iceberg-type lettuce compared with the long-term mean (LTM).

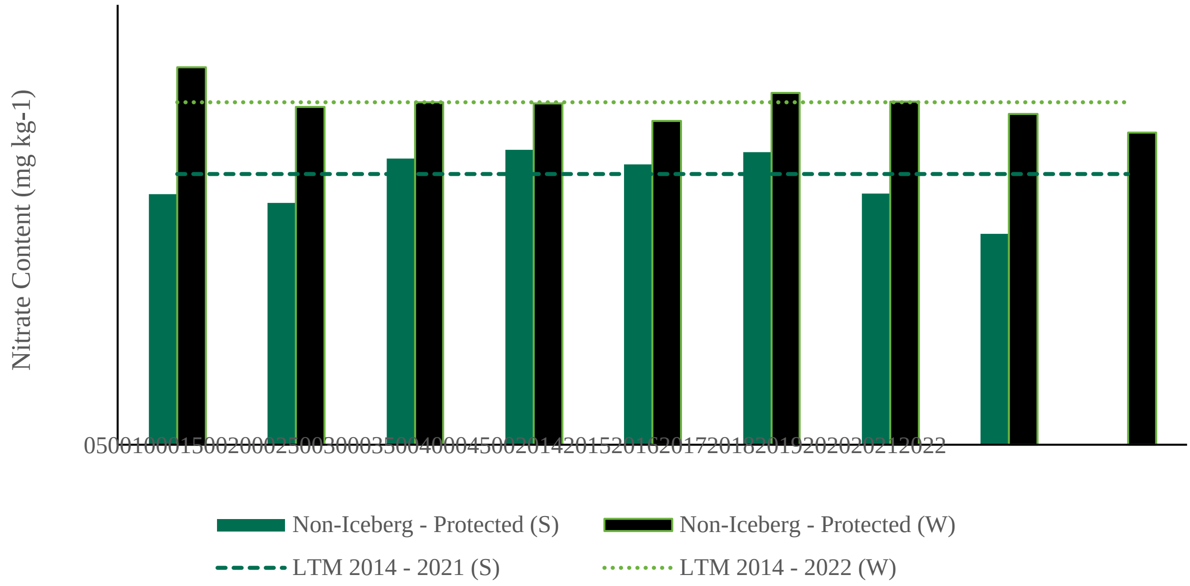

Figure 8. Comparison of annual average nitrate concentrations for protected non iceberg-type lettuce compared with the long-term mean (LTM).

Average nitrate concentrations in rocket were marginally lower than the long term mean (3809 vs. 4100 mg/kg - **Figure 9**). Average nitrate levels in Spinach in 2022 were almost double the long term mean (3833 vs. 1722 mg/kg - **Figure 10**). However, it should be noted that the 2022 average was based on only two samples (6600 and 1943 mg/kg) so that the presented average is likely to be impacted by sampling bias. Average concentrations in 2021 (1435 mg/kg based on 7 samples) were lower than the long term mean.

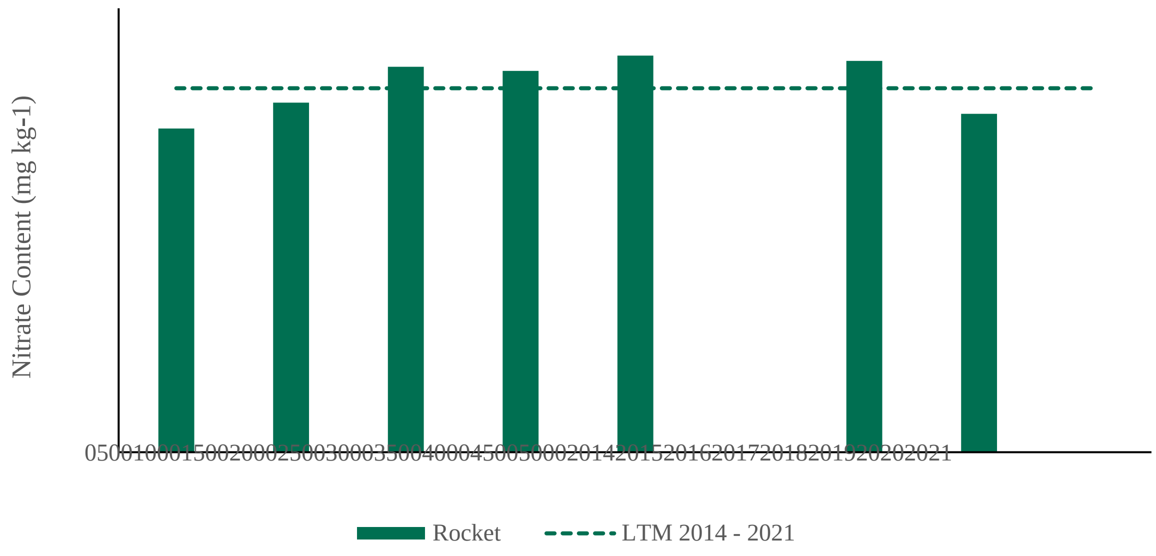

Figure 9. Comparison of annual average nitrate concentrations for rocket compared with the long-term mean (LTM).

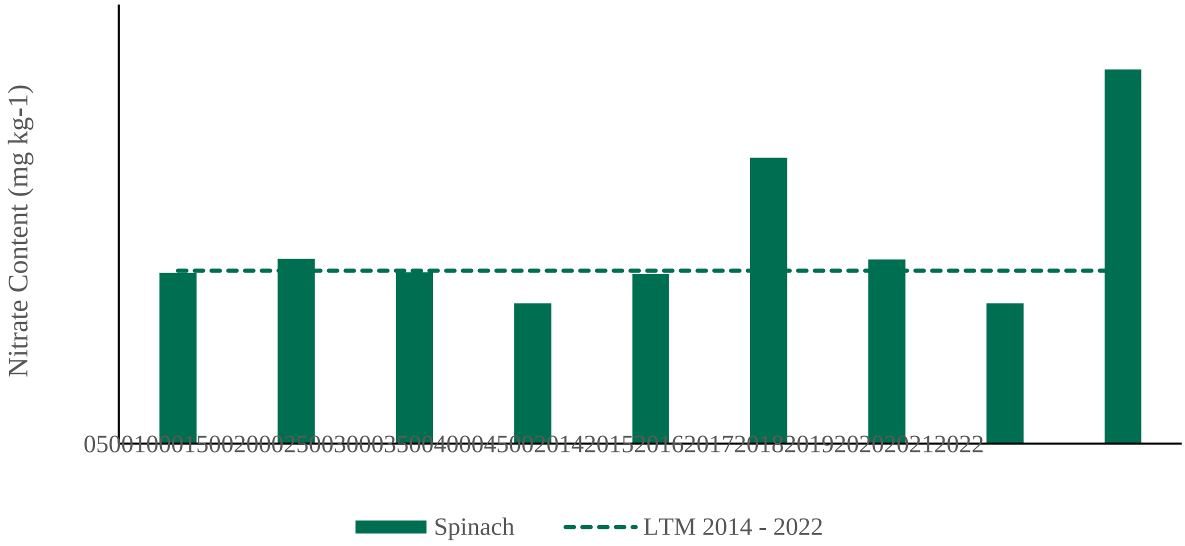

Figure 10. Comparison of annual average nitrate concentrations for spinach compared with the long-term mean (LTM).

Long term means for other leafy vegetables are not presented given variable sample group composition between years.

Samples Exceeding Regulation Limits

Four out of 125 samples (3.2%) collected in 2021 exceeded the regulation limit (NB. this value spans two report periods). The four exceedances were represented by two open air non-iceberg type samples, one protected non-iceberg sample and a spinach sample, all collected in the summer. A further three samples were within 10% of the maximum threshold in this period.

Whilst this is higher than 2020 (1.8%), this corresponds with the longer term trend of a decline in the proportions of samples exceeding regulated limits (**Figure 11**). Average percentages between 2002 – 2011 were 8.3% compared with 3.4% between 2012 – 2021.

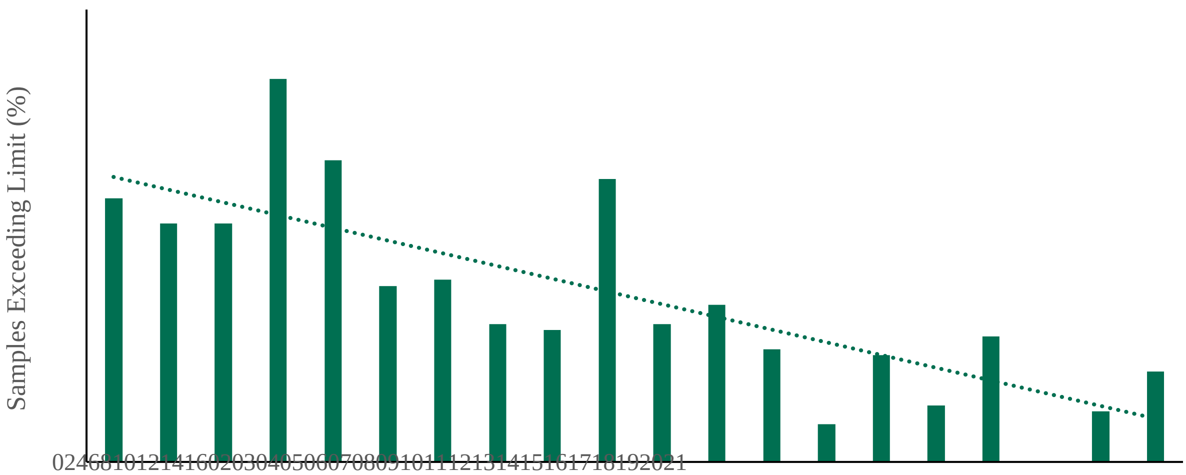

Figure 11. Annual percentages of UK samples collected between 2002 – 2021 which exceeded the regulation limit. Samples collected between Jan – March 2022 are not included. NB. Data for 2019 is not available.

When considered on a per-category basis, there have been no samples of open-air iceberg lettuce exceeding regulatory limits since 2014 (**Figure 12**). There has been a small but consistent proportion of open-air non-iceberg type lettuce which have exceeded regulatory limits in both 2020 and 2021, and this has increased from no samples in 2015-2017 (**Figure 13**). The proportion of protected non-iceberg type samples exceeding the regulatory levels in winter samples has remained at 0% since 2015. However, there have been relatively consistent exceedances in summer-sampled non-iceberg samples, although exceedances were the greatest in 2021 (11% of samples) since 2014 (**Figure 14**). There have been no exceedances in rocket since 2018 (**Figure 15**). Exceedance in spinach in 2021 had decreased compared with 2020 (reduced from 9.1% to 3.8% - **Figure 16**).

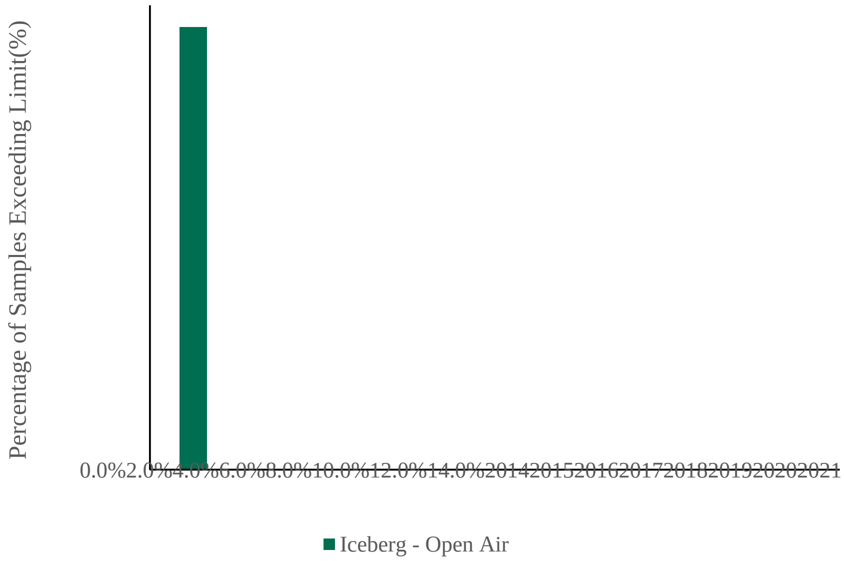

Figure 12. Proportion of open air iceberg lettuce exceeding regulation thresholds since 2014.

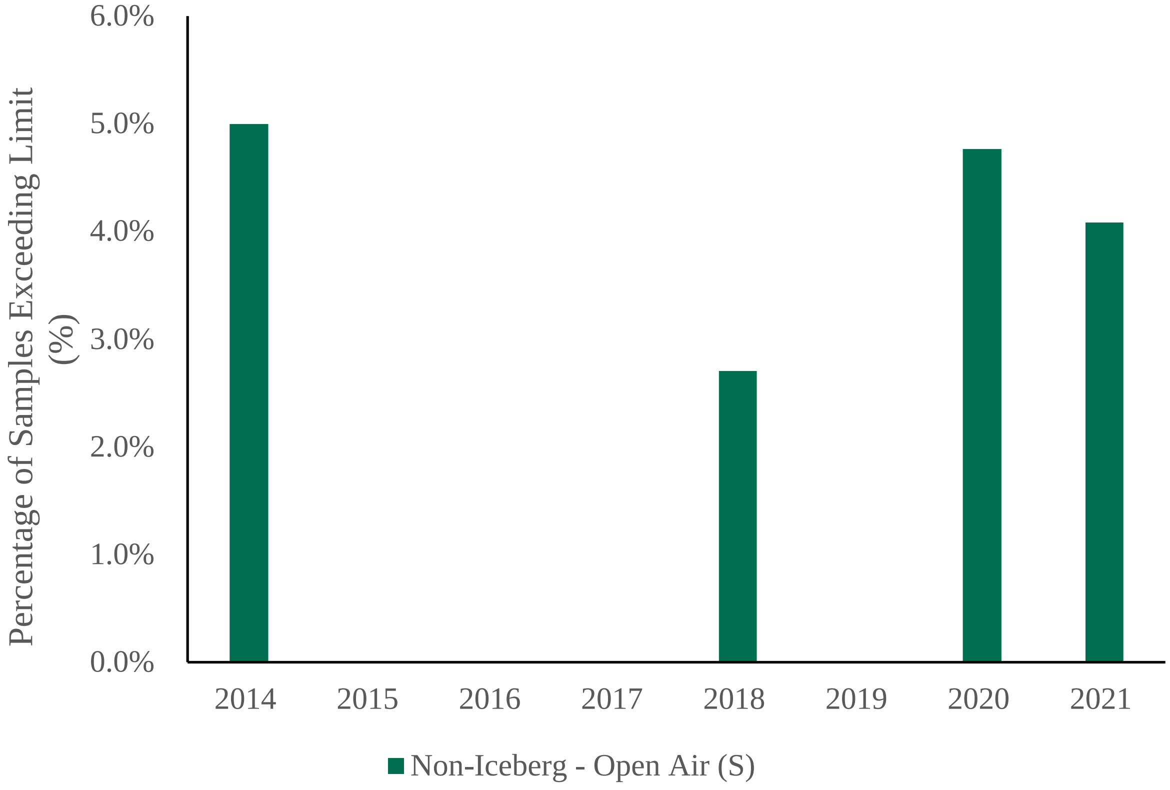

Figure 13. Proportion of open air non-iceberg lettuce exceeding regulation thresholds since 2014.

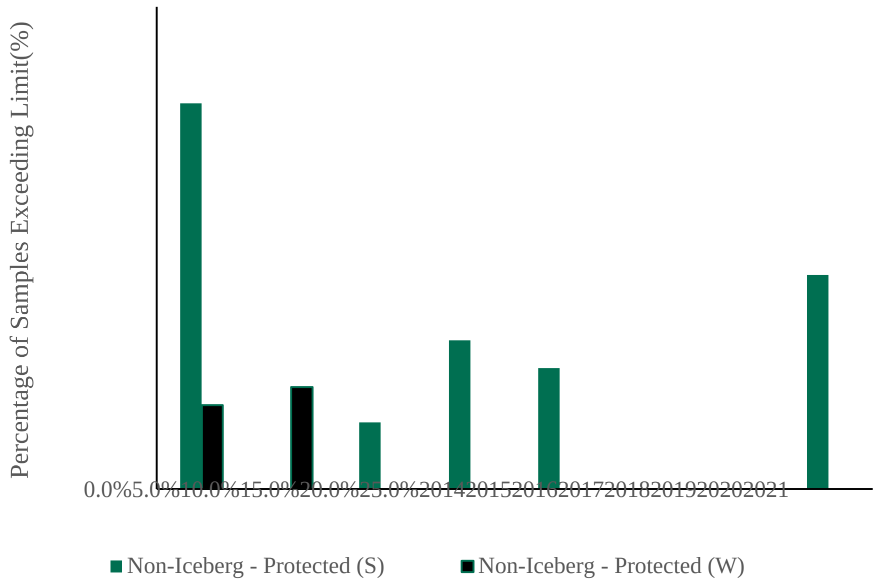

Figure 14. Proportion of protected non-iceberg lettuce exceeding regulation thresholds since 2014.

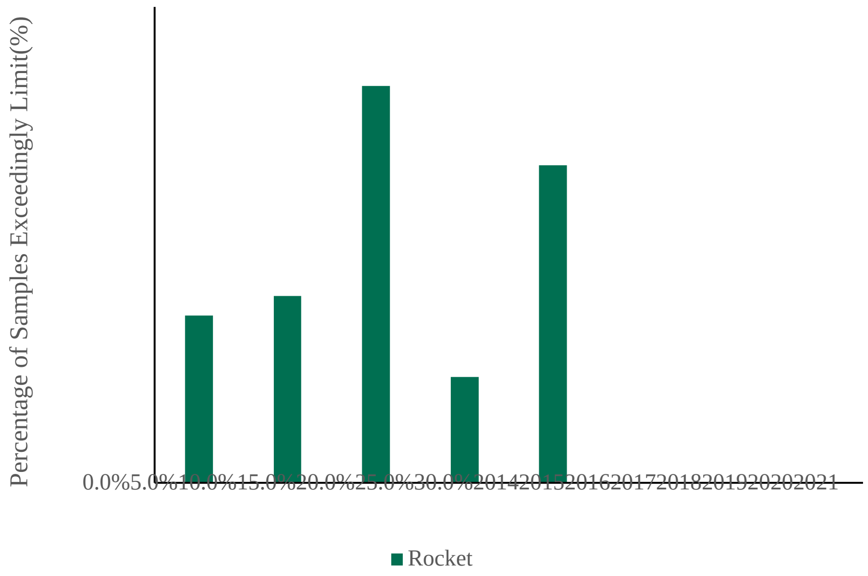

Figure 15. Proportion of rocket exceeding regulation thresholds since 2014.

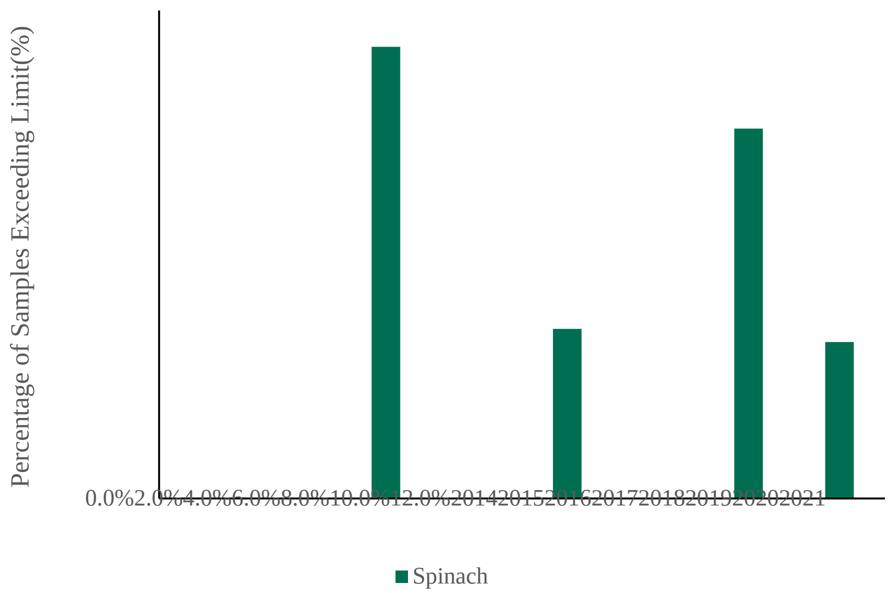

Figure 16. Proportion of spinach exceeding regulation thresholds since 2014.

Nitrate surveillance: Discussion

Evaluation of 2021 Results

The samples collected in the 2021/22 period continue to follow trends illustrated in previous years. Of primary note is that nitrate levels remain low in leafy salad products, with the proportion of samples exceeding the corresponding threshold remaining below 5% since 2014. The proportion of samples exceeding regulatory thresholds has varied between crop types since 2014: open air iceberg and rocket have been at 0% for a several successive years, whilst levels in non-iceberg types and spinach have remained marginally higher. Protected non-iceberg types generally show higher concentrations compared with open air iceberg and non-iceberg types. These results continue to show trends from previous years which indicate that risk factors for elevated nitrate concentrations are associated with variety, season and production method.

Nitrate levels vary significantly between product type, with iceberg lettuce typically showing lower concentrations than non-iceberg types, although there is significant variation from within both groups. Previous authors have reported strong correlations between variety and nitrate concentration (indicating that certain varieties may have an increased predisposition for accumulating excessive nitrate concentrations), although this may be linked to a range of other factors. Madar & Hájos (2021) noted that higher nitrate concentrations were seen in in those varieties with dark leaf colour (e.g. Romaine) compared with light varieties (e.g. Lolla Bionda), indicating that greater chlorophyll concentration was linked with greater nitrate accumulation. Other factors such as differing dry matter accumulation (and achieved water content) may also impact the achieved nitrate concentration - Dapoigny et al. (2000) also reported that there was a strong correlation between nitrate content and water accumulation in lettuce, so it is likely that climate conditions (e.g. temperature and rainfall) would interact with varietal predispositions for high levels of nitrate accumulation.

Besides the influence of variety it is indicated that planting date will also have a significant impact on nitrate accumulation risk.

Behr & Wiebe (1992) reported that nitrate content in lettuce increased with lower rates of photosynthesis seen under reduced temperatures. They hypothesised that increased nitrogen concentrations were seen in plants that achieved lower levels of accumulated sugars (as a result of lower rates of photosynthesis) to act an osmoticum to help plants balance water uptake and cell turgidity. However, it is difficult to separate out the ability of plants to convert nitrates to amino acids under conditions where there are reduced rates of photosynthesis.

The impact of temperature, rainfall and light levels reflects a further continuation a trends seen in seasonal variation in nitrate concentrations. Nitrate concentrations are generally lower in the late spring/early summer period, with levels increasing in the late summer through to early autumn. As discussed in previous reports this may be an artifact of the cultivation process, with later crops being grown with greater soil N availability due to the carry over of residues from early crops. However, there is also likely to be some interplay between nitrate concentrations and climate conditions, particularly light levels in the 5-15 days before harvest (Weightman et al., 2006; Roques & Weightman, 2010).

Weather in late winter in January/February 2021 saw extended periods of wet weather, with early plantings of lettuce and early brassica crops planted in brief dry periods in March. Leafy salad crops were also subject to low temperatures, with some crops being lost to late frosts in the East although conditions were generally cool in the spring. While the summer had higher temperatures, frequent rain ensured damp conditions particularly in the south where some crops were subject to flooding. Given the climate conditions in 2021, particularly the overly damp conditions, there is potential that the increased proportion of samples exceeding the threshold in 2021 relative to 2020 was seen.

This is likely to also interact with varietal effects - differing nitrate concentrations were seen in summer-grown vs. winter grown samples even within the same cultivar group (Escobar-Gutierrez et al., 2002). Given the potential impact of temperature, sunlight and soil moisture it is likely that environmental impacts are likely greater in significance compared to varietal choice – especially given that a broad range of cultivars were sampled in both periods to ensure that the diversity of variety choice is represented in the figures reported.

Overall, these data continue to contribute to a wider body of evidence that could be further examined to identify key risk factors associated with elevated nitrate concentrations.

Future Perspectives

Leafy salad production in the UK is currently subject to a several influences which may have an impact on nitrate levels both in 2021/22 and looking forward to further sampling years. Plantings of iceberg-type lettuce have been reduced since the onset of the covid-19 epidemic, particularly as a result of declines in the food service sector and increased popularity of bagged salad products. As growers increase proportions of non-iceberg types in cultivation this may feed forward into increased incidences of level exceedance given the predisposition of these varieties to accumulate nitrates to greater concentrations relative to iceberg.

In addition to changing consumer behaviour, the sector is becoming subject to increased prices in fertiliser and energy. Increased fertiliser prices as a result of the Ukrainian conflict are unlikely to lead to reductions in application, but growers may change how they are applying fertiliser to their crops which may in turn impact nitrate concentrations at harvest. Energy prices are likely to have an impact on overwintered protected production as growers may keeps crops cooler or delay planting due to high costs of heating that will be incurred as a result of elevated gas prices. Given the potential relationship between temperature, light and nitrate accumulation this could feed forward into changes in recorded nitrate concentrations.

Nitrate surveillance: References

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Nitrate Surveillance: Appendix 1

Download a fully copy of the data tables:

EXCEL
[View Nitrate Surveillance: Appendix 1 data tables as Excel(Open in a new window)] (84.71 KB)

			Sampling Month						Running Total					
June 2021		Max. permitted (mg NO_3/kg)	No. samples	Min. NO_3 (mg kg^{-1})	Max. NO_3 (mg kg^{-1})	Mean NO_3 (mg kg^{-1})	No. samples within 10% of Max	No. samples exceeding Max	No. samples	Min. NO_3 (mg kg^{-1})	Max. NO_3 (mg kg^{-1})	Mean NO_3 (mg kg^{-1})	No. samples within 10% of Max	No. samples exceeding Max
Lettuce non-iceberg type	*Harvested 01 October - 31 March*													
	Lettuce grown under cover	5000	0	0	0	0	0	0	0	0	0	0	0	0
	Lettuce grown in the open air	4000	0	0	0	0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0	0	0	0	0
	Harvested 01 April - 30 September		0	0	0	0	0	0	0	0	0	0	0	0
	Lettuce grown under cover	4000	0	0	0	0	0	0	3	597.2	1150.7	843.8	0	0
	Lettuce grown in the open air	3000	9	50	3157.7	707.4	1	1	14	50	3157.7	943.1214	1	1
			0	0	0	0	0	0	0	0	0	0	0	0
Iceberg type lettuce	Lettuce grown in the open air	2000	0	0	0	0	0	0	4	394.9	1701.3	837.9	0	0
			3	394.9	797	550.1	0	0						
			0	0	0	0	0	0	0	0	0	0	0	0
Spinach	*Fresh*	3500	1	213.9	213.9	213.9	0	0	10	92.6	2675	858.42	0	0
			0	0	0	0	0	0						
			0	0	0	0	0	0	0	0	0	0	0	0
Rocket	*Harvested 01 October - 31 March*	7000	0	0	0	0	0	0	0	0	0	0	0	0
	Harvested 01 April - 30 September	6000	0	0	0	0	0	0	3	1020.6	3986.6	2449.367	0	0
			0	0	0	0	0	0	0	0	0	0	0	0
Other leafy green veg		n/a	1	904.7	904.7	904.7	0	0	1	904.7	904.7	904.7	0	0
		Total	14				1	1	35				1	1

			Sampling Month						Running Total					
July 2021		Max. permitted (mg NO_3/kg)	No. samples	Min. NO_3 (mg kg^{-1})	Max. NO_3 (mg kg^{-1})	Mean NO_3 (mg kg^{-1})	No. samples within 10% of Max	No. samples exceeding Max	No. samples	Min. NO_3 (mg kg^{-1})	Max. NO_3 (mg kg^{-1})	Mean NO_3 (mg kg^{-1})	No. samples within 10% of Max	No. samples exceeding Max
Lettuce non-iceberg type	*Harvested 01 October - 31 March*													
	Lettuce grown under cover	5000	0	0	0	0	0	0	0	0	0	0	0	0
	Lettuce grown in the open air	4000	0	0	0	0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0	0	0	0	0
	Harvested 01 April - 30 September		0	0	0	0	0	0	0	0	0	0	0	0
	Lettuce grown under cover	4000	0	0	0	0	0	0	3	597.2	1150.7	843.8	0	0
	Lettuce grown in the open air	3000	11	478.4	1927	1144.545	0	0	25	50	3157.7	1031.748	1	1
			0	0	0	0	0	0	0	0	0	0	0	0
Iceberg type lettuce	Lettuce grown in the open air	2000	2	547.6	689	618.25	0	0	6	394.9	1701.3	764.6833	0	0
							0	0						
			0	0	0	0	0	0	0	0	0	0	0	0
Spinach	*Fresh*	3500	1	1141.9	1142	1141.9	0	0	11	92.6	2675	884.1909	0	0
							0	0						
							0	0	0	0	0	0	0	0
Rocket	*Harvested 01 October - 31 March*	7000	0	0	0	0	0	0	0	0	0	0	0	0
	Harvested 01 April - 30 September	6000	1	614.1	614	614.1	0	0	4	614.1	3986.6	1990.55	0	0
			0	0	0	0	0	0	0	0	0	0	0	0
Other leafy green veg		n/a	2	51.2	407	229.1	0	0	3	51.2	904.7	454.3	0	0
		Total	17				0	0	52				1	1

			Sampling Month						Running Total					
August 2021		**Max. permitted (mg NO_3/kg)**	**No. samples**	**Min. NO_3 (mg kg^{-1})**	**Max. NO_3 (mg kg^{-1})**	**Mean NO_3 (mg kg^{-1})**	**No. samples within 10% of Max**	**No. samples exceeding Max**	**No. samples**	**Min. NO_3 (mg kg^{-1})**	**Max. NO_3 (mg kg^{-1})**	**Mean NO_3 (mg kg^{-1})**	**No. samples within 10% of Max**	**No. samples exceeding Max**
Lettuce non-iceberg type	*Harvested 01 October - 31 March*													
	Lettuce grown under cover	5000	0	0	0	0	0	0	0	0	0	0	0	0
	Lettuce grown in the open air	4000	0	0	0	0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0	0	0	0	0
	Harvested 01 April - 30 September		0	0	0	0	0	0	0	0	0	0	0	0
	Lettuce grown under cover	4000	1	881.5	882	881.5	0	0	4	597.2	1150.7	853.225	0	0
	Lettuce grown in the open air	3000	13	50	2608	1118.208	0	0	38	50	3157.7	1061.326	1	1
			0	0	0	0	0	0	0	0	0	0	0	0
Iceberg type lettuce	Lettuce grown in the open air	2000	6	163	1606	1078.133	0	0	12	163	1701.3	921.4083	0	0
			0	0	0	0	0	0	0	0	0	0	0	0
Spinach	*Fresh*	3500	4	428	1669	1075.2	0	0	15	92.6	2675	935.1267	0	0
			0	0	0	0	0	0	0	0	0	0	0	0
Rocket	*Harvested 01 October - 31 March*	7000	0	0	0	0	0	0	0	0	0	0	0	0
	Harvested 01 April - 30 September	6000	2	1539	1579	1559	0	0	6	614.1	3986.6	1846.7	0	0
			0	0	0	0	0	0	0	0	0	0	0	0
Other leafy green veg		n/a	2	50	882	466.15	0	0	5	50	904.7	459.04	0	0
		Total	28				0	0	80				1	1

			Sampling Month						Running Total					
September 2021		**Max. permitted (mg NO_3/kg)**	**No. samples**	**Min. NO_3 (mg kg^{-1})**	**Max. NO_3 (mg kg^{-1})**	**Mean NO_3 (mg kg^{-1})**	**No. samples within 10% of Max**	**No. samples exceeding Max**	**No. samples**	**Min. NO_3 (mg kg^{-1})**	**Max. NO_3 (mg kg^{-1})**	**Mean NO_3 (mg kg^{-1})**	**No. samples within 10% of Max**	**No. samples exceeding Max**
Lettuce non-iceberg type	*Harvested 01 October - 31 March*													
	Lettuce grown under cover	5000	0	0	0	0	0	0	0	0	0	0	0	0
	Lettuce grown in the open air	4000	0	0	0	0	0	0	0	0	0	0	0	0
			0	0	0	0	0	0	0	0	0	0	0	0
	Harvested 01 April - 30 September		0	0	0	0	0	0	0	0	0	0	0	0
	Lettuce grown under cover	4000	5	822.9	4620.5	3203.48	1	1	9	597.2	4620.5	2158.922	1	1
	Lettuce grown in the open air	3000	11	585	3250	1218.136	1	1	49	50	3250	1096.529	2	2
			0	0	0	0	0	0	0	0	0	0	0	0
Iceberg type lettuce	Lettuce grown in the open air	2000	3	149	1391.4	959.2333	0	0	15	149	1701.3	928.9733	0	0
			0	0	0	0	0	0	0	0	0	0	0	0
Spinach	*Fresh*	3500	4	230	3819.1	1728.075	1	1	19	92.6	3819.1	1102.063	1	1
			0	0	0	0	0	0	0	0	0	0	0	0
Rocket	*Harvested 01 October - 31 March*	7000	0	0	0	0	0	0	0	0	0	0	0	0
	Harvested 01 April - 30 September	6000	0	0	0	0	0	0	6	614.1	3986.6	1846.7	0	0
			0	0	0	0	0	0	0	0	0	0	0	0
Other leafy green veg		n/a	3	2199	3731.3	2776.233	0	0	8	50	3731.3	1327.988	0	0
		Total	26				3	3	106				4	4

			Sampling Month						Running Total					
October 2021		**Max. permitted (mg NO_3/kg)**	**No. samples**	**Min. NO_3 (mg kg^{-1})**	**Max. NO_3 (mg kg^{-1})**	**Mean NO_3 (mg kg^{-1})**	**No. samples within 10% of Max**	**No. samples exceeding Max**	**No. samples**	**Min. NO_3 (mg kg^{-1})**	**Max. NO_3 (mg kg^{-1})**	**Mean NO_3 (mg kg^{-1})**	**No. samples within 10% of Max**	**No. samples exceeding Max**
Lettuce non-iceberg type	*Harvested 01 October - 31 March*													
	Lettuce grown under cover	5000	2	3687.1	4390.1	4038.6	0	0	2	3687.1	4390.1	4038.6	0	0
	Lettuce grown in the open air	4000	9	1037.4	2917.8	1763.078	0	0	9	1037.4	2917.8	1763.078	0	0
			0	0	0	0	0	0	0	0	0	0	0	0
	Harvested 01 April - 30 September		0	0	0	0	0	0	0	0	0	0	0	0
	Lettuce grown under cover	4000	0	0	0	0	0	0	9	597.2	4620.5	2158.922	1	1
	Lettuce grown in the open air	3000	0	0	0	0	0	0	49	50	3250	1096.529	2	2
			0	0	0	0	0	0	0	0	0	0	0	0
Iceberg type lettuce	Lettuce grown in the open air	2000	3	672.8	1386.1	966.1	0	0	18	149	1701.3	935.1611	0	0
			0	0	0	0	0	0	0	0	0	0	0	0
Spinach	*Fresh*	3500	3	448.5	3262	1720.867	0	0	22	92.6	3819.1	1186.445	1	1
			0	0	0	0	0	0						
			0	0	0	0	0	0	0	0	0	0	0	0
Rocket	*Harvested 01 October - 31 March*	7000	1	4158.5	4158.5	4158.5	0	0	1	4158.5	4158.5	4158.5	0	0
	Harvested 01 April - 30 September	6000	0	0	0	0	0	0	6	614.1	3986.6	1846.7	0	0
			0	0	0	0	0	0	0	0	0	0	0	0
Other leafy green veg		n/a	14	524.7	5540.6	2623.786	0	0	22	50	5540.6	2152.586	0	0
		Total	32				0	0	138				4	4

			Sampling Month						Running Total					
November 2021		Max. permitted (mg NO_3/kg)	No. samples	Min. NO_3 (mg kg^{-1})	Max. NO_3 (mg kg^{-1})	Mean NO_3 (mg kg^{-1})	No. samples within 10% of Max	No. samples exceeding Max	No. samples	Min. NO_3 (mg kg^{-1})	Max. NO_3 (mg kg^{-1})	Mean NO_3 (mg kg^{-1})	No. samples within 10% of Max	No. samples exceeding Max
Lettuce non-iceberg type	*Harvested 01 October - 31 March*													
	Lettuce grown under cover	5000	0	0	0	0	0	0	2	3687.1	4390.1	4038.6	0	0
	Lettuce grown in the open air	4000	0	0	0	0	0	0	9	1037.4	2917.8	1763.078	0	0
			0	0	0	0	0	0	0	0	0	0	0	0
	Harvested 01 April - 30 September		0	0	0	0	0	0	0	0	0	0	0	0
	Lettuce grown under cover	4000	0	0	0	0	0	0	9	597.2	4620.5	2158.922	1	1
	Lettuce grown in the open air	3000	0	0	0	0	0	0	49	50	3250	1096.529	2	2
			0	0	0	0	0	0	0	0	0	0	0	0
Iceberg type lettuce	Lettuce grown in the open air	2000	0	0	0	0	0	0	18	149	1701.3	935.1611	0	0
			0	0	0	0	0	0	0	0	0	0	0	0
Spinach	*Fresh*	3500	0	0	0	0	0	0	22	92.6	3819.1	1186.445	1	1
			0	0	0	0	0	0						
			0	0	0	0	0	0	0	0	0	0	0	0
Rocket	*Harvested 01 October - 31 March*	7000	0	0	0	0	0	0	1	4158.5	4158.5	4158.5	0	0
	Harvested 01 April - 30 September	6000	0	0	0	0	0	0	6	614.1	3986.6	1846.7	0	0
			0	0	0	0	0	0	0	0	0	0	0	0
Other leafy green veg		n/a	2	50	800.9	425.45	0	0	24	50	5540.6	2008.658	0	0
		Total	2				0	0	140				4	4

			Sampling Month						Running Total					
December 2021		Max. permitted (mg NO_3/kg)	No. samples	Min. NO_3 (mg kg^{-1})	Max. NO_3 (mg kg^{-1})	Mean NO_3 (mg kg^{-1})	No. samples within 10% of Max	No. samples exceeding Max	No. samples	Min. NO_3 (mg kg^{-1})	Max. NO_3 (mg kg^{-1})	Mean NO_3 (mg kg^{-1})	No. samples within 10% of Max	No. samples exceeding Max
Lettuce non-iceberg type	*Harvested 01 October - 31 March*													
	Lettuce grown under cover	5000	9	1648.2	4333.6	3258.056	0	0	11	1648.2	4390.1	3399.973	0	0
	Lettuce grown in the open air	4000	0	0	0	0	0	0	9	1037.4	2917.8	1763.078	0	0
			0	0	0	0	0	0	0	0	0	0	0	0
	Harvested 01 April - 30 September		0	0	0	0	0	0	0	0	0	0	0	0
	Lettuce grown under cover	4000	0	0	0	0	0	0	9	597.2	4620.5	2158.922	1	1
	Lettuce grown in the open air	3000	0	0	0	0	0	0	49	50	3250	1096.529	2	2
			0	0	0	0	0	0	0	0	0	0	0	0
Iceberg type lettuce	Lettuce grown in the open air	2000	0	0	0	0	0	0	18	149	1701.3	935.1611	0	0
			0	0	0	0	0	0	0	0	0	0	0	0
Spinach	*Fresh*	3500	0	0	0	0	0	0	22	92.6	3819.1	1186.445	1	1
			0	0	0	0	0	0						
			0	0	0	0	0	0	0	0	0	0	0	0
Rocket	*Harvested 01 October - 31 March*	7000	0	0	0	0	0	0	1	4158.5	4158.5	4158.5	0	0
	Harvested 01 April - 30 September	6000	0	0	0	0	0	0	6	614.1	3986.6	1846.7	0	0
			0	0	0	0	0	0	0	0	0	0	0	0
Other leafy green veg		n/a	2	350	5149.6	2749.8	0	0	26	50	5540.6	2065.669	0	0
		Total	11				0	0	151				4	4

			Sampling Month						Running Total					
January 2022		Max. permitted (mg NO_3/kg)	No. samples	Min. NO_3 (mg kg^{-1})	Max. NO_3 (mg kg^{-1})	Mean NO_3 (mg kg^{-1})	No. samples within 10% of Max	No. samples exceeding Max	No. samples	Min. NO_3 (mg kg^{-1})	Max. NO_3 (mg kg^{-1})	Mean NO_3 (mg kg^{-1})	No. samples within 10% of Max	No. samples exceeding Max
Lettuce non-iceberg type	*Harvested 01 October - 31 March*													
	Lettuce grown under cover	5000	10	2848.6	5548.6	4052.8	1	1	21	1648.2	5548.6	3710.843	1	1
	Lettuce grown in the open air	4000	0	0	0	0	0	0	9	1037.4	2917.8	1763.078	0	0
			0	0	0	0	0	0	0	0	0	0	0	0
	Harvested 01 April - 30 September		0	0	0	0	0	0	0	0	0	0	0	0
	Lettuce grown under cover	4000	0	0	0	0	0	0	9	597.2	4620.5	2158.922	1	1
	Lettuce grown in the open air	3000	0	0	0	0	0	0	49	50	3250	1096.529	2	2
			0	0	0	0	0	0	0	0	0	0	0	0
Iceberg type lettuce	Lettuce grown in the open air	2000	0	0	0	0	0	0	18	149	1701.3	935.1611	0	0
			0	0	0	0	0	0	0	0	0	0	0	0
Spinach	*Fresh*	3500	1	5814.3	5814.3	5814.3	1	1	23	92.6	5814.3	1387.657	2	2
			0	0	0	0	0	0						
			0	0	0	0	0	0	0	0	0	0	0	0
Rocket	*Harvested 01 October - 31 March*	7000	1	6599.6	6599.6	6599.6	0	0	2	4158.5	6599.6	5379.05	0	0
	Harvested 01 April - 30 September	6000	0	0	0	0	0	0	6	614.1	3986.6	1846.7	0	0
			0	0	0	0	0	0	0	0	0	0	0	0
Other leafy green veg		n/a	1	3365.3	3365.3	3365.3	0	0	27	50	5540.6	2113.804	0	0
		Total	13				2	2	164				6	6

			Sampling Month						Running Total					
February 2022		Max. permitted (mg NO_3/kg)	No. samples	Min. NO_3 (mg kg^{-1})	Max. NO_3 (mg kg^{-1})	Mean NO_3 (mg kg^{-1})	No. samples within 10% of Max	No. samples exceeding Max	No. samples	Min. NO_3 (mg kg^{-1})	Max. NO_3 (mg kg^{-1})	Mean NO_3 (mg kg^{-1})	No. samples within 10% of Max	No. samples exceeding Max
Lettuce non-iceberg type	*Harvested 01 October - 31 March*													
	Lettuce grown under cover	5000	0	0	0	0	0	0	31	1063.1	5548.6	3499.935	1	1
	Lettuce grown in the open air	4000	0	0	0	0	0	0	9	1037.4	2917.8	1763.078	0	0
			0	0	0	0	0	0	0	0	0	0	0	0
	Harvested 01 April - 30 September		0	0	0	0	0	0	0	0	0	0	0	0
	Lettuce grown under cover	4000	0	0	0	0	0	0	9	597.2	4620.5	2158.922	1	1
	Lettuce grown in the open air	3000	0	0	0	0	0	0	49	50	3250	1096.529	2	2
			0	0	0	0	0	0	0	0	0	0	0	0
Iceberg type lettuce	Lettuce grown in the open air	2000	0	0	0	0	0	0	18	149	1701.3	935.1611	0	0
			0	0	0	0	0	0	0	0	0	0	0	0
Spinach	*Fresh*	3500	0	0	0	0	0	0	24	92.6	5814.3	1512.442	3	3
			0	0	0	0	0	0						
			0	0	0	0	0	0	0	0	0	0	0	0
Rocket	*Harvested 01 October - 31 March*	7000	0	0	0	0	0	0	3	1942.7	6599.6	4233.6	0	0
	Harvested 01 April - 30 September	6000	0	0	0	0	0	0	6	614.1	3986.6	1846.7	0	0
			0	0	0	0	0	0	0	0	0	0	0	0
Other leafy green veg		n/a	0	0	0	0	0	0	30	50	6356	2416.707	0	0
		Total	0				0	0	179				7	7

			Sampling Month						Running Total					
March 2022		Max. permitted (mg NO_3/kg)	No. samples	Min. NO_3 (mg kg^{-1})	Max. NO_3 (mg kg^{-1})	Mean NO_3 (mg kg^{-1})	No. samples within 10% of Max	No. samples exceeding Max	No. samples	Min. NO_3 (mg kg^{-1})	Max. NO_3 (mg kg^{-1})	Mean NO_3 (mg kg^{-1})	No. samples within 10% of Max	No. samples exceeding Max
Lettuce non-iceberg type	*Harvested 01 October - 31 March*													
	Lettuce grown under cover	5000	14	875.7	4510.5	2671.507	0	0	45	875.7	5548.6	3242.202	1	1
	Lettuce grown in the open air	4000	0	0	0	0	0	0	9	1037.4	2917.8	1763.078	0	0
			0	0	0	0	0	0	0	0	0	0	0	0
	Harvested 01 April - 30 September		0	0	0	0	0	0	0	0	0	0	0	0
	Lettuce grown under cover	4000	0	0	0	0	0	0	9	597.2	4620.5	2158.922	1	1
	Lettuce grown in the open air	3000	0	0	0	0	0	0	49	50	3250	1096.529	2	2
			0	0	0	0	0	0	0	0	0	0	0	0
Iceberg type lettuce	Lettuce grown in the open air	2000	0	0	0	0	0	0	18	149	1701.3	935.1611	0	0
			0	0	0	0	0	0	0	0	0	0	0	0
Spinach	*Fresh*	3500	2	2348.2	2787	2567.6	0	0	26	92.6	5814.3	1593.608	3	3
			0	0	0	0	0	0						
			0	0	0	0	0	0	0	0	0	0	0	0
Rocket	*Harvested 01 October - 31 March*	7000	0	0	0	0	0	0	3	1942.7	6599.6	4233.6	0	0
	Harvested 01 April - 30 September	6000	0	0	0	0	0	0	6	614.1	3986.6	1846.7	0	0
			0	0	0	0	0	0	0	0	0	0	0	0
Other leafy green veg		n/a	7	50	7046.9	2994.829	0	0	37	50	7046.9	2526.081	0	0
		Total	23				0	0	202				7	7

Nitrate surveillance: Appendix 2

Letter used from January 2021 for samples collected in GB

Date
XXXX

Dear Sir/Madam,

Re: UK Nitrate Monitoring Programme

Thank you for your continued support of the UK Nitrate Monitoring Programme by allowing ADAS to collect field samples of your product, for analysis of nitrate content.

As you may be aware, GB retained law 1258/2011 came into force in December 2011. This Regulation amends GB retained law 1881/2006 which sets maximum limits for nitrate levels in lettuce and spinach, together with a statutory requirement for Member States to monitor nitrate levels in certain vegetables.

The GB retained law 1258/2011 has applied in the UK since 23 December 2011 and sets out new, permanent limits in green leafy vegetables; except the limits for rocket which applied specifically from 1 April 2012. It ends the previous temporary derogations which permitted the UK and some other EU countries to exceed maximum limits, without compromising consumer food safety, for fresh lettuce and spinach grown and intended for consumption on their own respective territories. Limits have also been included for rocket for the first time under this new Regulation.

Furthermore, the regulation now allows Member States to communicate results of the monitoring programme to the European Food Safety Authority (EFSA) on a regular basis, rather than the mandatory deadline of June 30 each year. This change will, however, not affect the programme. I have attached details of the permitted maximum nitrate limits in Appendix 1.

I am pleased to provide you with the analytical results for recent sample(s) of your product, collected as part of the monitoring programme, in Table 1. Data collected will be collated, anonymised and published by the Food Standards Agency.

Although the information we have provided is simply for your information, if you do find any analytical results for nitrate in produce from your farm that are above the maximum limits, then you may wish to verify your application of the Code of Good Agricultural Practice and the controls you have in place. It is, therefore, expected that any potential breaches of limits would be addressed through voluntary review of agronomic practices. Other action(s) could be considered in the event of a breach that presents a food safety concern. In this case the FSA would take appropriate action in the interest of consumer safety. Any additional data on nitrate in leafy vegetables you may have as part of your own monitoring would be most useful and such information can be submitted to the Food Standards Agency directly or via a Trade Association and will be treated in confidence.

If you have any queries about your results please feel free to contact me at the above address, or for more general queries about the monitoring programme, please contact Mr Ian Smith at the Food Standards Agency (Tel 020 7276 8375).

Yours sincerely

Angela Huckle
Associate Director
ADAS Horticulture
RSK ADAS Ltd
cc: Ian Smith, Food Standards Agency
Encs

Nitrate surveillance: Appendix 3

Name
Address

Reference:
Date:

Dear

re: UK NITRATE monitoring programme

Thank you for your continued support of the UK Nitrate Monitoring Programme by allowing RSK ADAS Ltd to collect field samples of your product, for analysis of nitrate content.

As you may be aware, a new Commission Regulation (EC) No 1258/2011 came into force in December 2011. This new Regulation amends Commission Regulation (EC) No 1881/2006 which sets maximum limits for nitrate levels in lettuce and spinach, together with a statutory requirement for an annual monitoring programme of nitrate levels in certain vegetables.

Commission Regulation (EC) No 1258/2011 has applied in the UK since 1 April 2012 and sets out new, permanent limits in green leafy vegetables. It ends the previous temporary derogations which permitted the UK and some other EU countries to exceed maximum limits, without compromising consumer food safety, for fresh lettuce and spinach grown and intended for consumption on their own respective territories. Limits have also been included for rocket for the first time under this new Regulation. Furthermore, the regulation now allows Member States to communicate results of the monitoring programme to the Commission on a regular basis, rather than the mandatory deadline of June 30 each year. This change will, however, not affect the programme. I am pleased to provide you with the analytical results for a recent sample of your product, collected as part of the monitoring programme, in Table 1. You should be aware that the level of nitrate found in the sample on this occasion exceeds limits set out in Commission Regulation (EC) No 1258/2011

The sample has been re-tested to confirm that the level is above the maximum limit. Both results are shown in Table 1 for your information. The Food Standards Agency does not intend to take any further action on this occasion. It is, however, expected that breaches of limits would be addressed through voluntary review of agronomic practices and regulatory action considered only after persistent breaches that threaten consumer safety. You may wish to be aware, though, that the data collected will be collated, anonymised and submitted by the Agency to the Commission, for statutory monitoring purposes.

Although the information we have provided is simply for your information, if you do find any analytical results for nitrate in produce from your farm that are above the limits specified in Commission Regulation (EC) No1258/2011, then you may wish to verify your application of the Code of Good Agricultural Practice and the controls you have in place.

Any additional data on nitrate in leafy vegetables you may have as part of your own monitoring would be most useful and such information can be submitted to the Food Standards Agency directly or via a Trade Association and will be treated in confidence.

If you have any queries about your results please feel free to contact me at the above address, or for more general queries about the monitoring programme, please contact Mr Ian Smith at the Food Standards Agency (Tel 020 7276 8375).

Yours sincerely

Angela Huckle
Associate Director
ADAS Horticulture
RSK ADAS Ltd

cc: Ian Smith, Food Standards Agency

Table 1: Results of samples taken

Grower	**Sampler**	**Sample Date**	**Sample ID**	**Sample type**	**Variety**	**Nitrate (mg NO3/kg)**	**Re-test Nitrate (mg NO3 /kg)**

-	-	-	-	-	-	-	-

Appendix 1

Maximum permitted levels of nitrates in fresh spinach and lettuce (under Commission Regulation (EU) No 1258/2011)

Products	Maximum permitted levels (mg NO3/kg)
Fresh spinach	/3500
Preserved, deep-frozen or frozen spinach	/2000
Fresh lettuce	Harvested 1 October to 31 March: Lettuce grown under cover /5000 Lettuce grown in the open air /4000 Harvested 1 April to 30 September: Lettuce grown under cover /4000 Lettuce grown in the open air /3000
Iceberg-type lettuce	Lettuce grown under cover /2500 Lettuce grown in the open air /2000

Letter used from January 2021 for samples collected in GB

Date: xxxx

Dear Sir/Madam,

Re: UK Nitrate Monitoring Programme

Thank you for your continued support of the UK Nitrate Monitoring Programme by allowing RSK ADAS Ltd to collect field samples of your product, for analysis of nitrate content.

As you may be aware, GB retained law 1258/2011 came into force in December 2011. This Regulation amends GB retained law 1881/2006 which sets maximum limits for nitrate levels in lettuce and spinach, together with a statutory requirement for Member States to monitor nitrate levels in certain vegetables.

The GB retained law 1258/2011 has applied in the UK since 1 April 2012 and sets out new, permanent limits in green leafy vegetables. It ends the previous temporary derogations which permitted the UK and some other EU countries to exceed maximum limits, without compromising consumer food safety, for fresh lettuce and spinach grown and intended for consumption on their own respective territories. Limits have also been included for rocket for the first time under this new Regulation. Furthermore, the regulation now allows Member States to communicate results of the monitoring programme to the Commission on a regular basis, rather than the mandatory deadline of June 30 each year. This change will, however, not affect the programme. I am pleased to provide you with the analytical results for a recent sample of your product, collected as part of the monitoring programme, in Table 1. You should be aware that the level of nitrate found in the sample on this occasion exceeds the maximum limits.

The sample has been re-tested to confirm that the level is above the maximum limit. Both results are shown in Table 1 for your information. The Food Standards Agency does not intend to take any further action on this occasion. It is, however, expected that breaches of limits would be addressed through voluntary review of agronomic practices and regulatory action considered only after persistent breaches that threaten consumer safety. You may wish to be aware, though, that the data collected will be collated, anonymised and published by the FSA.

Although the information we have provided is simply for your information, if you do find any analytical results for nitrate in produce from your farm that are above the maximum limits, then you may wish to verify your application of the Code of Good Agricultural Practice and the controls you have in place.

Any additional data on nitrate in leafy vegetables you may have as part of your own monitoring would be most useful and such information can be submitted to the Food Standards Agency directly or via a Trade Association and will be treated in confidence.
If you have any queries about your results please feel free to contact me at the above address, or for more general queries about the monitoring programme, please contact Mr Ian Smith at the Food Standards Agency (Tel 020 7276 8375).

Yours sincerely

Angela Huckle
Associate Director
ADAS Horticulture
RSK ADAS Ltd
cc: Ian Smith, Food Standards Agency

Nitrate Surveillance: Appendix 4

Field sampling and transportation of lettuce and spinach samples for the UK Nitrate Monitoring Programme.

Introduction

EC Regulation No. 1881/2006 requires Member States to monitor nitrate levels in lettuce and spinach. This document specifies the procedure to be followed for taking and transporting samples of lettuce and spinach to the laboratory in connection with the UK Monitoring Programme for nitrate.
Principle: Representative sampling of lettuce, or spinach, from the field in accordance with Commission Directive 1882/2006/EC. Transfer to suitable containers and transport to the laboratory under appropriate conditions. Complete and despatch the sample pro-forma to the laboratory.

Reference document

Commission Directive 1882/2006/EC of 20 Dec 2006 establishing Community methods of sampling for the official control of nitrate in lettuce. Official Journal of the European Communities. No. L364/25.

Materials and Equipment

Vegetable knife.
Suitable insulated box for sample transportation.
Ice packs. Sampling record pro-forma.

Procedures

1. Sampling and data logging

As far as possible samples should be taken at various places distributed throughout the lot. Avoid taking samples that are extensively spoiled. Also avoid taking samples from areas which appear to be unrepresentative of the field, and avoid taking samples from the extreme edges of the field

Take samples from a pattern similar to that on a "5-spot" die, or by walking a "W" pattern across the field, collecting a minimum of 10 heads of lettuce (or 10 spinach samples) to give a combined total minimum weight of 1 kg. Plants must be cut at ground level. Trim off outer leaves to ensure the lettuce plant resembles a marketable product. Samples must not be cut or broken to produce the laboratory samples.

Complete the "Sampling Record - UK Produce" pro-forma (Annex 1) and transfer this to a plastic bag to prevent damage in transit.

2. Transportation to the laboratory.

Place each set of (minimum) 10 vegetables in a clean, inert container offering adequate protection from contamination and damage in transit. Ensure that suitable ice packs are included with the sample to ensure that the sample temperature is maintained below 10 0C during transportation to the laboratory. Include the completed pro-forma. Arrange despatch to the laboratory without delay.
Transportation should ensure that samples arrive at the laboratory before 10.30am on the day after harvest.