

Nitrate monitoring in spinach and lettuce - surveillance programme

Area of research interest: [Chemical hazards in food and feed](#)

Study duration: 2009-01-01

Project code: FS111001, FS513408, FS101228

Conducted by: RSK ADAS Ltd

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Background

Introduction

The European Commission set maximum levels for nitrate in lettuce and spinach grown for consumption. Climatic conditions and levels of light have a major influence on the levels of nitrate in certain vegetables such as lettuce and spinach; in general, nitrate levels are higher in winter. In recognition of this direct effect of climatic conditions on the natural uptake of nitrates by plants, some member states had a special derogation (until December 2008, then extended) for higher nitrate maximum levels. Under these provisions member states were required to supply results of nitrate monitoring annually to the Commission.

The monitoring survey (FS111001) provided appropriate data for the extended period of the derogation. Domestic and imported lettuce, spinach, rocket and other leafy green vegetable samples were collected for each calendar year 2009 to 2013 with the survey period ending in April 2014.

Following an evaluation by the European Food Safety Authority (EFSA), the Commission established higher MLs permanently and a new Commission Regulation (EC) No 1258/2011 came into force in December 2011. This Regulation set out new, permanent nitrate limits in green leafy vegetables and in addition MLs for rocket. Member states are still required to submit monitoring data to EFSA.

On completion of the monitoring period in April 2014 a new survey was commissioned under project code FS513408 to continue monitoring for the period May 2014 to April 2019.

A further survey was commissioned, under project code FS101228 covering the period July 2020 to March 2025. The first year of the survey has been completed and the report is below.

Sampling and analysis

Domestic lettuce, spinach and other leafy green vegetables (baby leaf, chard, brassica, batavia (green and red), romaine, mustard, pak choi and leaf beet were collected from a suitable cross section of UK growers. Imported produce was also included. These samples were representative of the range of varieties grown in the UK and reflect various geographical locations, growing practices and seasonality.

Sampling was carried out in accordance with the requirements of EC Regulation 1882/2006 and details of grower, produce variety, location, sample lot size and crop husbandry details such as meteorological conditions and fertiliser input were recorded. Samples were prepared in the laboratory in accordance with the requirements of EC Regulation 1882/2006, and their nitrate levels measured by the analytical contractor. 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 is accredited to BS EN ISO 17025: 2005.

The determination of nitrate is based on the formation of a diazo compound between nitrite and sulphanilamide. This compound is then coupled with N-1-Naphthylethylenediamine di-hydrochloride to give a red azo dye. The colour is measured at 540 nm. 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 is calculated from the analysed nitrate value. Detection is based on flow injection colorimetry.

Standard QA/QC procedures are employed (including reference material, spiked samples and reagent blanks). 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 2mg/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.

Results

In general, nitrate concentrations in UK grown lettuce and spinach were influenced by the season with summer-grown crops having lower levels than those grown in the winter. Imported lettuce samples had a lower mean nitrate concentration than domestic lettuce samples and mean nitrate concentration in UK grown spinach was comparable to that of domestic lettuce. Protected UK grown lettuce crops had a higher mean nitrate concentration than lettuce grown in the UK, in the open air. Iceberg type lettuce had a considerably lower mean nitrate level than non-iceberg type lettuce. Growers were informed of the results. Where maximum limits were exceeded, they were required to review aspects of their agricultural practices that could have contributed to the exceedance. The monitoring results have been submitted annually to EFSA as required by the legislation.

Data for the calendar years 2008 to 2013 are published with this summary. The raw data includes details of the analytical method, sample description, sampling method and analytical results for nitrate concentration in both domestic and imported produce.

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Research Approach

Objective

This project aims to provide detailed and robust information required for the relevant controls to ensure that any risks from nitrates - through chronic exposure via food - do not pose a risk to public health.

The key objective of this work is to carry out the sampling of up to 250 (since reduced to 155 from 2011 - 2013 and 200 from 2014) samples of UK-grown and imported fresh produce. This is principally lettuce and spinach, but also includes other species such as rocket, baby leaf, chard, leaf beet and brassica samples - as may be requested by us.

UK occurrence data for nitrate in domestic and imported produce will be submitted to the European Food Safety Authority.

Approach

Domestic lettuce, spinach and other leafy green vegetables (baby leaf, chard, brassica, Batavia (green and red) romaine, mustard, pak choi and leaf beet) will be collected from a suitable cross section of UK growers. Imported produce will also be included.

The sampling plan takes account of the major seasonal fluctuations that can occur in nitrate levels in salad crops. Sample collection, preparation and analyses shall be in accordance with guidelines provided in Regulation (EC) No 1882/2006 and the quality assurance procedures adopted for the previous UK nitrate monitoring programmes.

Growers will be informed of the results of analyses of their samples. Where maximum limits have been exceeded, they will be expected to examine and/or review aspects of their agricultural practices that could have contributed to the results.

Summary results will be reported to us including the analytical data for tissue nitrate concentration in each sample, as well as the date sampled, field location and other grower information as provided by the samplers.

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Results

The survey comprised the collection of nitrate monitoring data for each year during the monitoring period 2009 to April 2014, and May 2014 to April 2019 for lettuce, rocket, spinach and other leafy green vegetables.

Nitrate concentrations in UK grown lettuce and spinach were influenced by the season with summer-grown crops having lower levels than those grown in the winter. Protected UK grown lettuce crops had a higher mean nitrate concentration than lettuce grown in the UK, in the open air. Iceberg type lettuce had a considerably lower mean nitrate level than non-iceberg type lettuce. Imported lettuce samples had a lower mean nitrate concentration than domestic lettuce samples and the mean nitrate concentration of UK grown spinach was comparable to that of domestic lettuce.

Results from the monitoring programme are broadly comparable with those obtained from previous years and have been submitted annually to EFSA.

May 2014 to April 2019 survey period

For UK grown produce rocket had the highest mean nitrate concentration (4131 mg/kg), the highest maximum nitrate concentration (8052 mg/kg-) and the greatest range of values (7990 mg/kg)

For all categories winter samples had a higher mean concentration than summer samples (3519 mg/kg- compared with 2830 mg/kg). However, the range was higher for summer samples and the proportion of samples exceeding the limit was also higher during the summer months

Iceberg lettuce grown in the field had the lowest mean nitrate concentration of all the categories and the smallest range

Mean annual nitrate concentrations in 2018 rose above their respective long term averages (LTA) for both summer and winter samples of non-iceberg open air lettuces;

The available data show that the percentage of samples (excluding rocket) exceeding the permitted nitrate concentration has fallen by approximately 3% every 5 years.

July 2020 to March 2025 survey period

Within the main categories, rocket had the greatest nitrate content (4258 mg kg⁻¹), reduced from 4590 mg kg⁻¹ in 2019.

On average iceberg lettuce had a higher nitrate content than in 2019 (2213 mg kg⁻¹, up from 1188 mg kg⁻¹). Spinach had the lowest nitrate content at 2027 mg kg⁻¹. In the "Other" category levels varied between <50 mg kg⁻¹ (savoy cabbage) to 6073 mg kg⁻¹ (Lamb's Cress).

Consistent with previous years of this project, a positive correlation was found between nitrate concentration and date of sampling. While summer concentrations may be increased under dry conditions, relatively good summer weather in 2020 means that this is unlikely to have impacted nitrate concentrations. Indeed, the warm, bright summer is likely to have had a positive impact on nitrate concentrations, helping to keep levels low.

Concentrations increased into the autumn and winter as day length and light inputs reduced, leading to greater accumulation due to reducing rates of nitrogen metabolism.

Research report

PDF

[View Nitrate Surveillance Programme Report 2014-2019 as PDF\(Open in a new window\)](#) (1.31 MB)

England, Northern Ireland and Wales

EXCEL

[View Nitrate Data 2008 to 2013 as Excel\(Open in a new window\)](#) (320.84 KB)

EXCEL

[View Nitrate Data 2015 as Excel\(Open in a new window\)](#) (626.88 KB)

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[View Nitrate Data 2019 as Excel\(Open in a new window\)](#) (529.97 KB)

England, Northern Ireland, Scotland and Wales

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