

# The microbiological examination of ready-to-eat organic vegetables from retail establishments in the United Kingdom

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**Aims:** A microbiological study of uncooked ready-to-eat organic vegetables was undertaken to determine the microbiological quality of these vegetables on retail sale in the UK.

**Methods and Results:** Organic vegetables were collected and examined according to a standardized protocol. The majority (3185 of 3200; 99.5%) of samples were found to be of satisfactory/acceptable quality whilst only 15 (0.5%) were of unsatisfactory quality.

Unsatisfactory results were due to *Escherichia coli* and *Listeria* spp. (not *L. monocytogenes*) levels in excess of  $10^2$  cfu g<sup>-1</sup>.

**Conclusions:** The absence of pathogens (*L. monocytogenes*, *Salmonella*, *Campylobacter* and *E. coli* O157) and the low incidence (1.5%) of *E. coli* and *Listeria* spp. associated with these organic vegetables indicates that overall agricultural, hygiene, harvesting and production practices were good.

**Significance and Impact of the Study:** There has been a significant expansion of the UK organic market since 1998/99. Of the various commodity sectors making up the organic market, fruit and vegetables is the largest sector and this has been reflected in an increased interest in their microbiological safety. This is the first study to provide information on the microbiological quality of organic vegetables.

## INTRODUCTION

Organic food is grown using those principles and techniques that predated the introduction of modern agrochemical and intensive farming techniques (Institute of Food Science and Technology (IFST) 1999). On-going food concerns, specifically about Bovine Spongiform Encephalopathy (BSE) and Genetically Modified (GM) foods are without doubt generating a significantly increased interest in organic food (House of Lords Select Committee on the European Communities 1999; House of Commons Agriculture Committee 2001). The word 'organic' may only be applied to crop products that have been grown, processed and packaged in accordance with the requirements of the European Community Council Regulation 2092/91 (EC Council 1991) (implemented in the UK as the Organic

Products Regulations 1992; as amended). All food sold as organic must come from growers, processors or importers who are registered and subject to regular inspection. In the UK, the United Kingdom Register of Organic Food Standards (UKROFS) ensures that the various UK certification bodies, such as the Soil Association, properly apply the Regulation. EC legislation for organic produce also require labels to indicate, by a unique code number, the organic certification body (e.g. in the UK, 1–7) with which the producer or packer is registered (MAFF 1998).

Organic food is a small but growing part of the food industry in the European Union, and its existence provides an element of consumer choice, for which there is growing demand (Soil Association 2000). From 1993 to 1998/99 the sale of organic food in the UK has risen markedly from £100 million to £390 million (Soil Association 1999). The largest sector is fruit and vegetables, and in 1998/99 this commodity area accounted for £175 m (45% of the total), of which 82% was imported. Overall, 70% of organic food was sold in supermarkets during 1998/99 (Soil Association 1999). With an annual market growth of 50%, it is estimated that by 2005 organic food in the UK will account for 20% of

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the total food market with a potential value of over £1 billion by early 2001 (House of Commons Agriculture Committee 2001; Soil Association 2001).

Manure and other animal wastes are widely used in agriculture, both organic and conventional. The use of manure as fertiliser, whether in organic or conventional agriculture, gives rise to concern about the possible contamination of produce with microbial pathogens, especially *Escherichia coli* O157 (IFST 1999). However, the Soil Association recommendations for manure storage and treatment on organic farms may lead to enhanced reductions to the levels of pathogens in stored manures that are to be spread to land (Soil Association 1999). The UK Food Standards Agency (FSA) view is that there is currently no firm evidence to support the assertion that organic produce is more or less microbiologically safe than conventionally farmed produce (FSA 2000). A recent review by the Ministry of Agriculture, Fisheries and Food (MAFF) also concludes that at present there is insufficient information to state categorically whether the risk of pathogen transfer to produce on organic farms differs significantly from the risk associated with conventional farming practice (MAFF 2000).

As a consequence of the lack of information concerning the microbiological quality of organic vegetables, despite their increased consumption, the Local Authorities Co-ordinating Body on Food and Trading Standards (LACOTS)/and the Public Health Laboratory Service (PHLS) Co-ordinated Food Liaison Group programme undertook a study on the microbiological quality of uncooked ready-to-eat organic vegetables on retail sale in the UK. The study was specifically not a comparative study of organic and conventionally produced vegetables.

## MATERIALS AND METHODS

### Sample collection

Ready-to-eat organic vegetables collected from retail outlets and doorstep delivery schemes were examined in PHLS and non-PHLS laboratories in the UK between 1st May and 30th June 2000 according to a standardized protocol and reporting system. Vegetables included in the study were those that could be consumed without any cooking or further preparation by the consumer other than portioning as necessary and light washing and/or scraping. Vegetables sampled (approx. 150 g) were those that were grown in close proximity or in contact with soil (e.g. broccoli, cabbage, carrot, cauliflower, celeriac, celery, cress, lettuce, mushrooms, radish, spring onions, watercress), and other salad vegetables, such as cucumber, pepper and tomato. Samples were collected from supermarkets, health food stores, greengrocers, farmshops/markets, market stalls, doorstep

box-scheme deliveries and warehouse/storage area box-schemes by staff from local Environmental Health Departments and were transported to the laboratory in accordance with the Food Safety Act 1990, Code of Practice No. 7 (2000).

Information on the organic vegetable samples and outlets was obtained by observation and enquiry and recorded on a standard proforma. This included the country of origin, organic certification body number, packaging, and details concerning the retail display of the product.

### Isolation of bacteria

Samples were collected and examined within their 'best before date' or 'display date'. *Escherichia coli* was enumerated in accordance with PHLS Standard Method for Food Products F20 (PHLS 1998a). Enumeration of *Listeria* spp. and *L. monocytogenes* was based on the British Standard (BS) ISO 11290-2: Part 2 (BSI 1998), using Oxford Listeria Agar incubated at 30°C in place of PALCAM agar incubated at 37°C. *Campylobacter* spp., *Salmonella* spp., *E. coli* O157 were detected in accordance with PHLS Standard Methods for Food Products F21 (PHLS 1998b), F13 (PHLS 1998c) and F17 (PHLS 1998d), respectively.

## RESULTS

A total of 3200 ready-to-eat organic vegetable samples were collected by 52 Local Authority Food Liaison Groups, involving 350 Local Authorities, for examination in 43 laboratories (30 PHLS and 13 non-PHLS) in England, Wales, Scotland and Northern Ireland.

### Micro-organisms isolated from ready-to-eat organic vegetables

*Escherichia coli* was detected in 1.5% (48/3200) of ready-to-eat organic vegetable samples, and was present at  $10^2$  cfu g<sup>-1</sup> or more in 0.3% (11) samples (Table 1). *Listeria* spp. (not including *L. monocytogenes*) were detected in 0.2% (six) samples, and were present at  $10^2$  cfu g<sup>-1</sup> or more in 0.1% (four) samples. Further characterization of the two *Listeria* spp. found in excess of  $10^3$  cfu g<sup>-1</sup> revealed the organisms to be *L. innocua* (from a sample of watercress) and *L. seeligeri* (from a sample of radish). *Listeria monocytogenes*, *Salmonella* spp., *Campylobacter* spp. and *E. coli* O157 were not detected in any of the samples examined.

### Microbiological quality of ready-to-eat organic vegetables

Based on the PHLS Microbiological Guidelines for some ready-to-eat foods sampled at the point of sale (Table 2;

**Table 1** Microbiological results of ready-to-eat organic vegetables ( $n = 3200$ )

	ND* in 25 g	< 20 <sup>†</sup>	20–< 10 <sup>2</sup>	10 <sup>2</sup> –< 10 <sup>3</sup>	10 <sup>3</sup> –< 10 <sup>4</sup>	10 <sup>4</sup> –< 10 <sup>5</sup>	10 <sup>5</sup> –< 10 <sup>6</sup>	10 <sup>6</sup> –< 10 <sup>7</sup>	≥ 10 <sup>7</sup>	NE <sup>‡</sup>
<i>Escherichia coli</i>		3150**	37	9	2					2
<i>Listeria</i> spp.		3192**	2	2	2					2
<i>L. monocytogenes</i>		3198**								2
<i>Campylobacter</i> spp.	2883									317§
<i>Salmonella</i> spp.	3196									4
<i>Escherichia coli</i> O157	3193									7

\*ND, not detected.

<sup>†</sup>NE, not examined (full set of microbiological parameters not performed on sample due to insufficient sample collected).

<sup>‡</sup>cfu g<sup>-1</sup>.

§These were not examined due to unavailability of the selective supplement cycloheximide during May–June 2000.

\*\*Lower limit of detection 20 cfu g<sup>-1</sup>.

**Table 2** PHLS guidelines for the microbiological quality of some ready-to-eat foods sampled at the point of sale: key to classification for fresh vegetables

Criterion	Microbiological quality (cfu g <sup>-1</sup> unless stated)			
	Satisfactory	Acceptable	Unsatisfactory	Unacceptable/ potentially hazardous
<i>Escherichia coli</i>	< 20	20–< 10 <sup>2</sup>	≥ 10 <sup>2</sup>	N/A*
<i>Listeria</i> spp.	< 20	20–< 10 <sup>2</sup>	≥ 10 <sup>2</sup>	N/A
<i>Listeria monocytogenes</i>	< 20	20–< 10 <sup>2</sup>	N/A	≥ 10 <sup>2</sup>
<i>Campylobacter</i> spp.	Not detected in 25 g			Detected in 25 g
<i>Salmonella</i> spp.	Not detected in 25 g			Detected in 25 g
<i>Escherichia coli</i> O157	Not detected in 25 g			Detected in 25 g

\*N/A, not applicable.

PHLS 2000), 3146 (98.5%) of 3200 ready-to-eat organic vegetables were satisfactory, 39 (1%) acceptable, and 15 (0.5%) were of unsatisfactory microbiological quality. *Escherichia coli* and *Listeria* spp. (not *L. monocytogenes*) were the microbiological parameters associated with unsatisfactory results. None of the samples examined were of unacceptable microbiological quality.

A major feature of the data is that of the micro-organisms tested (Table 1), none were found in 3146 of the 3200 (98.5%) samples examined. This forms the vast majority of the data. Therefore information collected on the organic vegetable samples and outlets (described below) had no significant effect on the microbiological quality of the vegetables with regard to samples of unsatisfactory quality (data not shown), i.e. no correlation was found between samples of unsatisfactory quality and product information.

## Product information

**Types of ready-to-eat organic vegetables.** A total of 21 different vegetable types were examined (Table 3). The majority of the vegetables examined were grown in close

proximity or in contact with the soil (74%; 2349/2300) with the remainder being nonsoil contact vegetables (26%; 851).

**Type of outlet.** Over three-quarters (79%; 2528/3200) of samples were collected from supermarkets, 214 (7%) from health food shops, 175 (5%) from farm shops/markets, 70 (2%) from greengrocers, 54 (2%) from doorstep box-scheme deliveries, 37 (1%) from market stalls, and 24 (1%) from warehouse/storage areas. Other outlets (butchers, garden centre, nursery shop and organic product specialist) accounted for 76 (2%). For 36 (1%) of outlets visited this information was not recorded (Fig. 1).

**Packaging and display.** Of the ready-to-eat organic vegetables sampled (3200), 2586 (81%) were prepacked vegetables and 567 (18%) were unwrapped or loose on sale. For the remaining 47 (1%) of samples this information was not recorded. The vast majority of samples obtained from supermarkets (96%; 2434/2528) were prepacked. Most of the samples (96%; 3067/3200) collected were displayed and stored in a clean environment as judged by the Sampling Officer, while 59 (2%) were not. For 74 (2%) of samples this

**Table 3** Types of ready-to-eat organic vegetables ( $n = 3200$ )

Organic vegetable type	Number of samples	%
Those grown in close proximity or in contact with soil ( $n = 2349$ ):		
Broccoli	209	7
Cabbage	159	5
Carrot	478	15
Cauliflower	70	2
Celeriac	11	< 1
Celery	193	6
Cress	12	< 1
Lettuce	415	13
Mushrooms	425	13
Radish	17	< 1
Spring onions	87	3
Water cress	65	2
Other (spinach, leeks, shallots, chard)	208	7
Non soil contact vegetables ( $n = 851$ ):		
Cucumber	221	7
Pepper	184	6
Tomato	428	13
Other (babycorn, cherry tomato)	18	< 1
<b>Total</b>	<b>3200</b>	<b>100</b>

information was not recorded. A quarter of samples (24%; 770) collected had visible soil contamination; however, most did not (73%; 2339). For the remaining 91 (3%) of samples this information was not recorded. Of the samples that did have visible soil contamination most were unwrapped or loose on sale (78%; 590/770).

**Country of origin.** Of the 3200 organic vegetables sampled, the majority were imported (70%; 2240), with most originating from Spain (31%) and the Netherlands (15%) (Table 4). Of the 30% (943) of samples produced in the UK, nearly a quarter (24%; 226/943) originated in England; however, most (67%; 634/943) samples specified UK only.

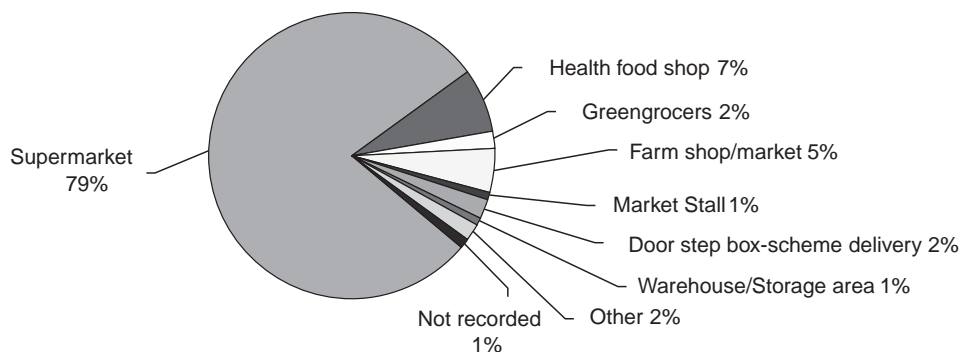
**Identification as organic (certification body number).** The majority (81%; 2585/3200) of organic ready-

to-eat vegetable samples were identified as organic by labelling containing a UK certification body number (Fig. 2), and of these almost three-quarters (74%; 1919) were by the Soil Association. The remainder (11%; 364) was identified as organic by other EC Member State certification bodies. However, for 252 (8%) of samples this information was not known.

## DISCUSSION

This study has shown that the vast majority (99.5%) of uncooked ready-to-eat organic vegetables sampled at retail in the UK were of satisfactory/acceptable microbiological quality. Only 0.5% were classed as unsatisfactory according to published guidelines (PHLS 2000). Unsatisfactory results were due to *E. coli* and *Listeria* spp. (not *L. monocytogenes*) counts at  $10^2$  cfu  $g^{-1}$  or more. *Escherichia coli* is a faecal organism and both *E. coli* and *Listeria* spp. are environmental micro-organisms that are found in soil and water. Therefore, vegetables may easily become contaminated with these bacteria. However, the absence of pathogens and the low incidence (1.5%) of *E. coli* and *Listeria* spp. associated with these organic vegetables indicates that overall agricultural, hygiene, harvesting and production practices were good.

The greatest growth in organic sales has been through the main multiple retailers (supermarkets). More consumers will have access to these outlets on a national basis than can be reached by other distribution methods, such as farmers' markets and box schemes (House of Commons Agriculture Committee 2001). In this study, over three-quarters (79%) of vegetables were collected from supermarkets and this may reflect the continued phenomenal growth of the organic market that has occurred since 1998/99 (annual market growth of 100% during the last two years) (House of Commons Agriculture Committee 2001; Soil Association 2001). Overall, 80% of fresh fruit and vegetables sold in the UK are imported (Durbury 2000). A lower proportion (70%) of imported vegetables was examined in this study. However, vegetables were collected during the months of

**Fig. 1** Ready-to-eat organic vegetables collected from retail outlets ( $n = 3200$ )

**Table 4** Country of origin of ready-to-eat organic vegetables collected ( $n = 3200$ )

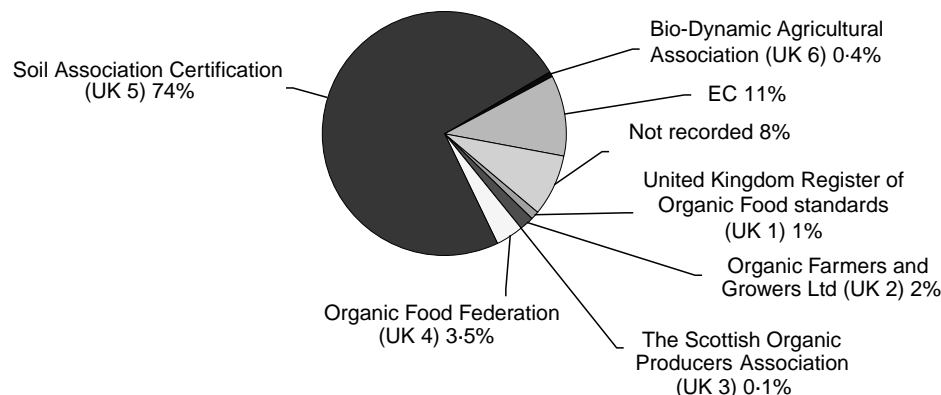
Country of origin	Number of samples	%
United Kingdom ( $n = 943$ ):	943	30
England	226	24.0
Northern Ireland	12	1.0
Scotland	8	1.0
Wales	63	7.0
UK	634	67.0
Other EC countries ( $n = 1774$ ):		
Austria	6	< 1
Belgium	47	2
France	90	3
Germany	1	< 1
Greece	2	< 1
Ireland	2	< 1
Italy	176	5
Netherlands	464	15
Portugal	7	< 1
Spain	979	31
Third countries ( $n = 316$ ):		
Argentina	8	< 1
Canary Islands	38	1
Channel Islands	1	< 1
Egypt	23	1
Israel	162	5
Mexico	51	2
Morocco	1	< 1
New Zealand	10	< 1
Tunisia	3	< 1
USA	17	< 1
Zambia	1	< 1
Zimbabwe	1	< 1
Produce of two or more countries (not UK)	19	< 1
Not recorded	148	5
Total	3200	100

May and June and this may reflect market supply due to the seasonality of growing vegetables in the field. Presentation of organic vegetables sold by supermarkets is generally in a prepacked format. This is partly to do with the need to retain the integrity of the organic vegetables as well as to provide information to consumers via labelling (Durbury 2000). This is reflected by the findings in this study where most (81%) of the organic vegetables sampled were prepacked.

Between 1992 and 1999 foodborne outbreaks made up over a third (35%; 1408/4083) of general outbreaks reported from England and Wales, and of these foodborne outbreaks, ready-to-eat fruit and vegetables accounted for a very small proportion (4.3%; 60 affecting 2170 people) (O'Brien *et al.* 2000). This is the first such study to provide information on the microbiological quality of uncooked ready-to-eat organic vegetables. This study was not a comparative study and therefore did not aim to produce conclusive evidence that organically produced vegetables are more or less microbiologically safe than those produced conventionally. Such an investigation would also require a detailed microbiological risk assessment to be undertaken. However, all food sold, whether organically or conventionally produced, must by law satisfy food safety requirements (Food Safety Act 1990). The information and experience gained from this present study could help to determine the requirements for further studies into this product area. In addition, information from the study can be used to help formulate microbiological guidelines.

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**Fig. 2** Ready-to-eat vegetables identified as organic (certification body number) ( $n = 3200$ )

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