

LACORS/HPA Co-ordinated Food Liaison Group Studies: Microbiological Assessment of Fresh Herbs from Retail Premises in the United Kingdom Uncovers an International Outbreak of Salmonellosis

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**On behalf of the Local Authorities Co-ordinators of Regulatory Services (LACORS) and
the Health Protection Agency (HPA)**

Summary

This Local Authorities Co-ordinators of Regulatory Services / Health Protection Agency study was prompted by the increasing concern regarding the microbiological safety of ready-to-eat salad vegetable products, particularly fresh herbs. During May to October 2007, 3760 ready-to-eat fresh herbs, of different varieties, were sampled across the UK to assess their microbiological safety in relation to salmonella contamination and levels of *Escherichia coli*.

Sixty (1.6%) herb samples were found to be of unsatisfactory quality according to the Regulation (EC) No. 2073/2005 on the microbiological criteria of foodstuffs, i.e. contaminated with *Salmonella* spp. and/or containing *E. coli* at $\geq 10^3$ cfu/g. When criteria in the Microbiological Guidelines for some ready-to-eat foods were used, 117 (3.9%) of herb samples were of unsatisfactory quality due to the presence of salmonella and/or *E. coli* at $\geq 10^2$ cfu/g.

Eighteen (0.5%) samples of six different herb types were contaminated with *Salmonella* spp.: identified as serotypes Senftenberg (8), Agona (2), Anatum (1), Durban (1), Javiana (1), Mgulani (1), Montevideo (1), Unnamed (l 16:g, t: z42) (1), Virchow (1) and mixed Newport & Virchow (1). In each case the retailer and the UK Food Standards Agency were immediately informed and remedial action taken. Samples contaminated with *S. Senftenberg* were specifically associated with basil grown in Israel. Thirty-two human cases of *S. Senftenberg* infection were subsequently identified throughout England and Wales and a further 19 in Scotland, Denmark, The Netherlands and the USA. The strain of *S. Senftenberg* identified from

the basil samples and that from cases had an indistinguishable molecular profile, suggesting a likely connection between consumption of basil and human infection.

The presence of *Salmonella* spp. is unacceptable in ready-to-foods such as fresh herbs. This study highlights the necessity of applying good agricultural and hygiene practices pre-, during and post-harvest, at processing, retail and use. These practices help to prevent cross-contamination and/or bacterial growth occurring in these products. Best practice is to store and display such products at or below 8°C as this inhibits bacterial growth.

Introduction

Fresh herbs are commonly used as a food ingredient in both the commercial and domestic setting. The majority of fresh herbs can be consumed raw or added to food after cooking, depending on local culinary practices. Used in this way, herbs are considered to be in a ready-to-eat state. Regulation (EC) No. 2073/2005 on microbiological criteria for foodstuffs defines ready-to-eat food as “food intended by the producer or manufacturer for direct human consumption without the need for cooking or other processing effective to eliminate or reduce to an acceptable level micro-organisms of concern” (EC, 2005a).

Fresh vegetables, including herbs, from around the world have now become available to consumers throughout the European Union (EU) year-round. This underlines the need for the international application of good hygiene standards for such produce. Strategies for preventing fresh vegetables from being contaminated with microorganisms of concern (e.g. *Salmonella* spp., *Campylobacter* spp., Vero cytotoxin-producing *Escherichia coli* and *Listeria monocytogenes*) during production rely on control measures taken pre-, during and post-harvest (Codex, 2003; CFA, 2007; FPC, 1999; Knight and Stanley, 2002; US FDA/CFSSAN, 2008). Food safety controls, underpinned by the application of Good Agricultural Practices, Good Manufacturing Practices, Good Hygiene Practices, and implementation of a hazard analysis critical control point (HACCP) system, are employed to ensure that food reaching the consumer is in line with EU food hygiene legislation and thereby safe to eat (EC, 2004, 2005a).

The World Health Organization (WHO) and the Food and Agriculture Organization of the United Nations (FAO) have concluded that leafy green vegetables, including fresh herbs, present the greatest concern in terms of microbiological hazards associated with fresh produce (FAO/WHO, 2008). This assessment was based on the number of outbreaks of gastrointestinal illness associated with these products, and the large volume in which these products are grown and exported following complex production chains. Moreover, within Europe during 2005 and 2006, there were 87 and 33 Rapid Alert System for Food and Feed (RASFF) notifications respectively, reporting microbiological contamination (including pathogenic micro-organisms) of fresh herbs and spices (EC, 2005b, 2006).

In the UK during 2005 and 2006 three regional investigations by the Health Protection Agency (HPA) identified salmonella contamination of various fresh herbs. In 2005, 13.1% (32/244) of imported fresh herbs from non-EU countries examined at the point of entry (Border Inspection Post) in London were contaminated with *Salmonella* spp. (serotypes: Augustenborg, Brunei, Houten, Hvitvingfoss, Newport, Senftenberg, Rubislaw, Singapore, Stanley, Typhimurium definitive phage type (DT) 13, Weltevreden, Unnamed (I 4,12: b:-)). The fresh herbs in which *Salmonella* was detected included four varieties of basil (sweet, holy, lemon, and tree basil) grown in Thailand (Surman-Lee et al. 2008).

In 2006, a pan-London retail study of fresh herbs showed that 1.7% (5/298) of samples were contaminated with *Salmonella* spp. (serotypes: Newport, Uphill, Virchow phage type (PT) 21, Weltevreden and Unnamed (I Rough: r: z6)). The herb types contaminated included coriander, curry leaves and holy basil. The contaminated curry leaf and basil samples were known to be grown in India and Thailand, respectively (Surman-Lee et al. 2008). Also in 2006, a study of retail fresh herbs in East Midlands isolated *S. Abony* from a sample of pre-packed mint grown in Israel (D Jarvis and C Sharp, HPA personal communication). These findings indicated that fresh herbs could be a potential source of microbial contamination in the UK, particularly when used as ready-to-eat foods.

In 2007, in response to these HPA regional investigations, the Local Authorities Co-ordinators of Regulatory Services (LACORS) and the HPA Co-ordinated Food Liaison Group programme undertook a microbiological study of fresh herbs on retail sale across the UK to gain insight into the frequency and types of *Salmonella* spp. in this ready-to-eat food product. The study aimed to include a variety of herbs as they were harvested in different countries and imported to the UK over the duration of the study.

Materials and Methods

Sample collection

A total of 3760 ready-to-eat fresh herb samples collected from retail premises were examined by 30 Official Food Control Laboratories in the UK between 1st May and 31st October 2007. Reflecting the use of the product by the final consumer, ready-to-eat fresh herbs included those that were available loose or in a bunch, pre-packed or grown in a pot. Dried herbs were specifically excluded from the study. Samples (≥ 50 g) were collected and transported to laboratories by staff from 319 local Environmental Health Departments, involving 52 Local Authority Food Liaison Groups (Annex 1). Samples were collected and transported in accordance with the Food Standards Agency's Food Law Code of Practice (FSA, 2006) and the LACORS guidance on microbiological food sampling (LACORS, 2006). Information on samples and premises was obtained by observation and enquiry and recorded on a standard

questionnaire. The questionnaire included information on the premises, type of fresh herb, packaging, country of origin and retail display or storage temperature (Annex 2).

Sample examination

The presence or absence of *Salmonella* spp. was determined and level of *E. coli* enumerated in accordance with HPA Standard Microbiological Methods (HPA 2005a, 2005b, 2007a). All isolates of *Salmonella* spp. were sent to the Laboratory of Enteric Pathogens, HPA Centre for Infections for further characterisation. This included serotyping, phage typing, antimicrobial susceptibility testing and plasmid profile typing (Bale et al., 2007; Chambers et al., 1987; Frost, 1994; Kado and Liu 1981). Molecular analyses by pulsed field gel electrophoresis (PFGE) were based on the method described by Gatto et al. (2006), with designations of profile types in accordance with the Salm-Gene nomenclature (Peters et al., 2003).

Microbiological results were compared with Regulation (EC) No. 2073/2005 (as amended) on microbiological criteria for foodstuffs (EC, 2005a, 2007) and the PHLS Guidelines for the Microbiological Quality of Some Ready-to-eat Foods sampled at the Point of Sale (PHLS, 2000). These criteria are summarised in Table 1.

Table 1. Microbiological criteria for *Salmonella* spp. and *E. coli* in ready-to-eat fresh herbs

Micro-organism	Microbiological quality (cfu/g unless stated)		
	Satisfactory	Acceptable	Unsatisfactory
<i>Salmonella</i> spp. ^{a,b}	Not detected in 25g	-	Detected in 25g ^d
<i>E. coli</i> ^c	$\leq 10^2$	$>10^2 - \leq 10^3$	$>10^3$
<i>E. coli</i> ^b	<20	20 - $<10^2$	$\geq 10^2$

^a Pre-cut herbs, food safety criteria in Regulation (EC) No. 2073/2005 (as amended) (EC, 2007)

^b Ready-to-eat herbs, Guidelines for the microbiological quality of some ready-to-eat foods (PHLS, 2000)

^c Process hygiene criteria (point of production) in Regulation (EC) No. 2073/2005 (as amended) (EC, 2007)

^d Unacceptable quality. Potentially injurious to health and/or unfit for human consumption (contravenes Article 14 Food safety requirements of Regulation (EC) No. 178/2002 (General Food Law Regulation) (EC, 2002a)

Statistical analysis

Descriptive and statistical analysis of the data was undertaken using Microsoft Excel and GraphPad Software (GraphPad Software, Inc., USA). Relative proportions were compared using the Chi squared test (χ^2) and Fisher's exact test. A probability value of less than 5% was defined as significant.

Results

Prevalence of *Salmonella* spp. in ready-to-eat fresh herbs

Salmonella spp. were detected in 18 of 3760 (0.5%) ready-to-eat fresh herb samples (Table 2). The 18 herb samples contaminated with *Salmonella* spp. were all pre-cut herbs (14 were sold pre-packaged, four as open loose bunches). The presence of *Salmonella* spp. in pre-cut ready-to-eat herbs is legally unsatisfactory as this exceeds the food safety criteria in Regulation (EC) No. 2073/2005 (as amended). Ready-to-eat foods contaminated with *Salmonella* spp. are unsafe. They are considered to be injurious to health and/or unfit for human consumption as they contravene the food safety requirements (Article 14) of Regulation (EC) No.178/2002 (EC, 2002a).

Ten different salmonella serotypes were obtained from the 18 contaminated herb samples (Table 2). Eight samples of pre-packed pre-cut basil produced by a single grower in Israel were all contaminated with *S. Senftenberg*. *Escherichia coli* levels in these eight samples ranged from < 20 to 2.0×10^2 cfu/g. The other 10 samples of different herbs (coriander (3), curry leaves (2), mint (1), parsley (2), sweet basil (1) and walleria (1)) contained nine further salmonella serotypes as described in Table 2. *Escherichia coli* levels in these samples ranged from <20 to 1.6×10^4 cfu/g. *S. Agona* PT RDNC (RDNC does not conform to a designated phage type) isolated from two samples of herbs (coriander, walleria) exhibited resistance to tetracyclines. None of the other salmonella isolates exhibited antimicrobial resistance.

Further characterisation of the *S. Senftenberg* isolates from the pre-cut basil using PFGE and plasmid profiling identified all eight to have an indistinguishable PFGE profile designated as SSFTXB.0014 and to be carrying four plasmids, of 6.3, 4.5, 4.2 and 3.0 kilobases. Thirty-two cases of illness involving this strain of *S. Senftenberg* (the outbreak strain) were subsequently identified in England and Wales from 5 March to 6 June 2007. Scotland, Denmark, the Netherlands, and the USA also reported on 19 cases infected with the outbreak strain of *S. Senftenberg* from January to June 2007 (Pezzoli et al., 2008).

Table 2. *Salmonella* spp. and *E. coli* isolated from retail ready-to-eat fresh pre-cut herbs

Fresh herb	Packaging	Country of origin	Date sampled	Display until date	<i>Salmonella</i> serotypes and phage types	<i>E. coli</i> (cfu/g)
Basil	Pre-packed	Israel	08/05/07	10/05/07	Senftenberg	1.2 x 10 ²
Basil	Pre-packed	Israel	15/05/07	15/05/07	Senftenberg	<20
Basil	Pre-packed	Israel	17/05/07	18/05/07	Senftenberg	<20
Basil	Pre-packed	Israel	16/05/07	16/05/07	Senftenberg	<20
Basil	Pre-packed	Israel	22/05/07	24/05/07	Senftenberg	2.0 x 10 ²
Basil	Pre-packed	Israel	24/05/07	24/05/07	Senftenberg	<20
Basil	Pre-packed	Israel	24/05/07	25/05/07	Senftenberg	<20
Basil	Pre-packed	Israel	22/05/07	26/05/07	Senftenberg	<20
Parsley	Loose bunch	NK ^a	15/05/07	NK	Mgulani	8.8 x 10 ²
Mint	Loose bunch	NK	31/05/07	NK	Durban	>10 ³
Curry leaves	Pre-packed at shop	NK	05/06/07	NK	Newport, Virchow PT 8	1.6 x 10 ⁴
Coriander	Pre-packed	Spain	03/07/07	07/07/07	Unnamed (II 16:g, t: z42)	<20
Parsley	Pre-packed	Israel	25/07/07	31/07/07	Montevideo	5.2 x 10 ²
Curry leaves	Loose bunch	NK	23/08/07	NK	Virchow PT 21	<20
Sweet basil	Loose bunch	NK	19/09/07	NK	Javiana	3.8 x 10 ³
Coriander	Loose bunch	NK	26/09/07	NK	Agona PT RDNC ^b	<20
Walleria	Loose bunch	NK	26/09/07	NK	Agona PT RND	6 x 10 ²
Coriander	Pre-packed	Spain	01/10/07	03/10/07	Anatum	<20

^a Not known due to lack of available details

^b Reacts with typing phages, but does not conform to a known type

Comparison of interpretative guidance for *E. coli* levels in ready-to-eat fresh herbs

Comparison of the interpretative guidance available for *E. coli* levels in the fresh ready-to-eat herbs (Table 3) identified that the PHLS Guidelines (PHLS, 2000) were more stringent than the process hygiene criteria given in Regulation (EC) No. 2073/2005 (as amended) (EC, 2007).

Of the samples tested, only pre-cut herbs (pre-packaged, or retailed as a cut open bunch) could be compared by both sets of criteria (Table 1). Of these 3018 samples, 95.6% (2893) and 98.6% (2976) were of satisfactory or acceptable microbiological quality for *E. coli* using the PHLS Guidelines and Regulation (EC) 2073/2005 (as amended), respectively (PHLS, 2000; EC, 2007).

In the samples from which *Salmonella* spp. was isolated, the *E. coli* levels remained satisfactory for ten of the samples, irrespective of the criteria used (Table 3). According to the PHLS Guidelines (PHLS, 2000), the remaining eight samples were all considered of unsatisfactory microbiological quality due to the levels of *E. coli* present. Using the criteria in Regulation (EC) No. 2073/2005 (as amended) (EC, 2007), three of these samples were classified as of unsatisfactory microbiological quality and the remaining five as being of acceptable quality.

Table 3. Comparison of the PHLS Guidelines and Regulation (EC) No. 2073/2005 for *E. coli* microbiological quality in relation to detection of *Salmonella* spp. from pre-cut ready-to-eat herbs

<i>E. coli</i> microbiological quality (cfu/g)		<i>Salmonella</i> spp. in 25g	
		Detected (%) n = 18	Not detected (%) n = 3000
PHLS Guidelines ^a	Satisfactory (<20)	10 (0.3)	2772 (91.8)
	Acceptable (20 to <10 ²)	0	111 (3.7)
	Unsatisfactory (≥10 ²)	8 (0.3)	117 (3.9)
Regulation (EC) No. 2073/2005 ^b	Satisfactory (≤10 ²)	10 (0.3)	2883 (95.5)
	Acceptable (>10 ² to ≤10 ³)	5 (0.2)	78 (2.6)
	Unsatisfactory (>10 ³)	3 (0.1)	39 (1.3)

^a Guidelines for the microbiological quality of some ready-to-eat foods (PHLS, 2000)

^b Food category 2.5.1, process hygiene criteria (point of production) in Regulation (EC) No. 2073/2005 (as amended) (EC, 2007)

To allow full comparison of the *E. coli* results from this study, the PHLS Guideline levels were used for the following analyses, unless otherwise stated.

Fresh herb characteristics in relation to presence of salmonella, and *E. coli* at ≥10² cfu/g

Most herb samples (68.5%) collected were parsley (20.6%), coriander (19.5%), basil (17.9%), and mint (10.5%) (Table 4). *Salmonella* spp. was detected in six different herb varieties; basil (1.3%), coriander (0.4%), mint (0.3%), parsley (0.3%), curry leaves (10.0%; 2 out of 20 samples) and walleria (one sample). *Escherichia coli* at ≥10² cfu/g was also found in a variety of different herb types (basil, chives, coriander, dill, mint, parsley, tarragon, and other herbs) with an incidence of between 1.4 and 6.4%.

Sixty one percent of the herb samples were pre-cut and pre-packed, 19.8% were packed in an open container (growing herbs in pots) and 18.8% were open cut bunches (Table 4). *Salmonella* spp. was only detected in pre-cut herb samples (0.6% pre-packed, 0.6% open bunches) (p<0.0001). A greater proportion of samples containing *E. coli* at ≥10² cfu/g were found in pre-cut herb samples (4.2% in pre-packed herbs, 3.9% in open bunches) compared to those packed in open containers (1.6%) (p=0.0006).

Of the packaged samples (n = 3051), 86.3% had instructions for use on the packaging (Table 4). Most (85.0%) advised to 'wash before use' and 1.3% were labelled 'washed and ready to use'. *Salmonella* spp. was detected in 0.4% of packaged herbs labelled with instructions 'wash before use', and 0.7% in those with no instructions. More samples containing *E. coli* at ≥10² cfu/g had no instructions for use on the packaging (6.2%) compared with those that did (2.5-3.1%) (p=0.0040).

Ninety-eight percent of herb samples were not labelled as organic (Table 4). *Salmonella* spp. was recovered from 0.5% of samples not labelled as organic. *Escherichia coli* at ≥10² cfu/g

were present in a similar proportion of herbs that were labelled or not as organic products, 3.8% and 3.6%, respectively.

Table 4. Fresh herbs details in relation to presence of *Salmonella* spp. and *E. coli* at $\geq 10^2$ cfu/g

Fresh herb details	No. samples (%) n = 3760	No. salmonella (%) n = 18	No. <i>E. coli</i> $\geq 10^2$ cfu/g (%) n = 137
Fresh herb type			
Basil	674 (17.9)	9 (1.3)	21 (3.1)
Chives	219 (5.8)	0	3 (1.4)
Coriander	733 (19.5)	3 (0.4)	34 (4.6)
Dill	216 (5.7)	0	10 (4.6)
Fennel	17 (0.5)	0	0
Mint	397 (10.5)	1 (0.3)	13 (3.3)
Oregano	41 (1.1)	0	0
Parsley	774 (20.6)	2 (0.3)	23 (3.0)
Sage	81 (2.2)	0	0
Tarragon	121 (3.2)	0	2 (1.7)
Other (rosemary, thyme, methi, curry leaves, walleria)	487 (13.0)	3 ^a (0.6)	31 (6.4)
Packaging type			
Pre-packed (pre-cut)	2309 (61.4)	14 (0.6)	97 (4.2)
Packed in an open container (e.g. growing herbs in pots)	742 (19.8)	0	12 (1.6)
Open (loose pre-cut bunch)	709 (18.8)	4 (0.6)	28 (3.9)
Instructions for use on packaged herbs (n = 3051)			
Washed & ready to use	39 (1.3)	0	1 (2.5)
Wash before use	2594 (85.0)	11 (0.4)	82 (3.1)
No instructions	418 (13.7)	3 (0.7)	26 (6.2)
Labelled as organic			
Yes	80 (2.1)	0	3 (3.8)
No	3680 (97.9)	18 (0.5)	134 (3.6)

^a curry leaves (2), walleria (1)

Country of origin of fresh herbs in relation to presence of *Salmonella* spp. and *E. coli* at $\geq 10^2$ cfu/g

The majority of herbs sampled were grown in either the UK (38.5%) or Israel (28.3%) (Table 5). *Salmonella* spp. was detected in herbs grown in Spain (1.9%) and Israel (0.8%). *Salmonella* was also detected from one sample that was grown in Sri Lanka and in 0.8% of samples were the country of origin was not known. *Escherichia coli* at $\geq 10^2$ cfu/g were found in herbs grown in a wide range of different countries with incidence between 1.2 to 52.9%.

Table 5. Country of origin of fresh herbs in relation to presence of *Salmonella* spp. and *E. coli* at $\geq 10^2$ cfu/g

Country	No. samples (%) n = 3760	No. salmonella (%) n = 18	No. <i>E. coli</i> $\geq 10^2$ cfu/g (%) n = 137
Channel Islands	115 (3.1)	0	3 (2.6)
Cyprus	19 (0.5)	0	1 (5.3)
India	11 (0.3)	0	8 (52.9)
Israel	1063 (28.3)	9 (0.8)	37 (3.5)
Italy	23 (0.6)	0	1 (4.3)
Morocco	83 (2.2)	0	1 (1.2)
Netherlands	84 (2.2)	0	1 (1.2)
Spain	156 (4.1)	3 (1.9)	3 (1.9)
Thailand	15 (0.4)	0	4 (26.7)
UK	1448 (38.5)	0	36 (2.5)
Produce of > 1 country ^a	53 (1.4)	0	1 (1.9)
Other ^b	33 (0.9)	1 ^c (3.0)	3 (9.1)
Not known (no details available)	657 (17.5)	5 (0.8)	38 (5.8)

^a countries not specified

^b Other countries included; Canary Islands (8), China (1), Colombia (3), France (5), Germany (1), Ghana (1), Kenya (5), Republic of Ireland (3), South Africa (3), Sri Lanka (1), Turkey (2)

^c Sri Lanka

Type of premises and display/storage of fresh herbs in relation to presence of salmonella and *E. coli* at $\geq 10^2$ cfu/g

Over two-thirds (68.8%) of herb samples were collected from supermarkets (68.8%), with *Salmonella* spp. detected in 0.5% of these samples (Table 6). However, a greater proportion of herb samples collected from convenience stores were contaminated with *Salmonella* spp. (2.5%) ($p=0.0026$). More herb samples collected from convenience stores also contained *E. coli* at $\geq 10^2$ cfu/g (11.8%) compared to herbs collected from other premises types (2.6 – 9.5%) ($p<0.0001$).

The majority of the fresh herbs sampled were on display inside the premises (94.6%) (Table 6). Market stalls (45%; 50/111), convenience stores (22%; 53/237) and farm shops (18.0%; 33/185) were more likely to display herbs outside the premises compared to other premises types (greengrocer (6.0%; 37/578), supermarket (1.0%; 21/2586), other (16.0%; 10/63)). There was no difference in the proportion of samples contaminated with *Salmonella* spp. according to whether they were displayed within or outside the premises (0.5%). Samples collected from an outside display were more likely to contain *E. coli* at $\geq 10^2$ cfu/g (5.9%) compared to those sampled from inside the premises (3.5%) ($p>0.05$).

Most fresh herbs were stored or displayed at $>8^\circ\text{C}$ (77.4%) (Table 6). There was no difference in the type of premises and proportion of samples stored or displayed at $>8^\circ\text{C}$ (market stall (73.0%; 81/111), farm shop (75.0%; 138/185), convenience shop (78.0%; 186/237), supermarket (78.0%; 2005/2586), greengrocer (79.0%; 457/578), other types (67.0%;

42/63). *Salmonella* was only detected in herbs displayed at >8°C (0.6%, temperature ranging from 10.3 to 22.0°C) (p=0.0196). *Escherichia coli* at $\geq 10^2$ cfu/g were found in a similar proportion of herbs displayed at $\leq 8^\circ\text{C}$ or $>8^\circ\text{C}$, i.e. in 4.6% and 3.4% of samples, respectively.

Table 6. Premises details of where fresh herbs were obtained in relation to presence of *Salmonella* spp. and *E. coli* at $\geq 10^2$ cfu/g

Retail premises details	No. samples (%) n = 3760	No. salmonella (%) n = 18	No. <i>E. coli</i> $\geq 10^2$ cfu/g (%) n = 137
Premises type			
Supermarket	2586 (68.8)	12 (0.5)	67 (2.6)
Greengrocer	578 (15.4)	0	23 (4.0)
Convenience shop	237 (6.3)	6 (2.5)	28 (11.8)
Market stall	111 (3.0)	0	6 (5.4)
Farm shop	185 (4.9)	0	7 (3.8)
Other (e.g. butcher, delicatessen)	63 (1.6)	0	6 (9.5)
Product displayed			
Inside premises	3556 (94.6)	17 (0.5)	125 (3.5)
Outside premises	204 (5.4)	1 (0.5)	12 (5.9)
Storage/display temperature			
$\leq 8^\circ\text{C}$	796 (21.1)	0	37 (4.6)
$> 8^\circ\text{C}$ (8.1 – 37.0°C)	2909 (77.4)	18 ^a (0.6)	100 (3.4)
Not specified	55 (1.5)	0	0

^a temperature range of 10.3 – 22.0°C

Discussion

The microbiological safety of fresh vegetables, including herbs, has become of concern worldwide (FAO/WHO, 2008). The globalisation of food supplied in the fresh produce sector brings with it a large number of variables, from the food items themselves to a range of processing systems. The contamination of fresh produce could be the result of contamination during growth or through cross-contamination during processing, packaging or retail. This study has shown that the majority of ready-to-eat fresh herbs sampled were of satisfactory or acceptable microbiological quality based on published microbiological criteria (EC, 2007; PHLS, 2000). Eighteen (0.5%) of the herbs were contaminated with *Salmonella* spp. and, thus, were of unsatisfactory microbiological quality and considered to be potentially injurious to health and/or unfit for human consumption (EC, 2002a; 2007).

Ten salmonella serotypes were recovered from these 18 samples, with 44% being *S. Senftenberg* isolated from nationally distributed imported fresh basil. Following the isolation of *S. Senftenberg* from the basil in the UK, 51 infections caused by the same strain were recognised in cases of infection across the UK and also in Denmark, the Netherlands and the

USA (Pezzoli et al., 2008). Phenotypic and molecular techniques (pulsed field gel electrophoresis and plasmid profiling) proved invaluable in discriminating the outbreak strain from other strains of *S. Senftenberg* circulating in the UK and elsewhere at that time (Pezzoli et al., 2008). Investigations into the source of the fresh basil contaminated with salmonella linked it to a single grower in Israel who exported fresh basil to the USA, North Europe and Russia. The UK FSA, local authority environmental health departments, and UK retailers involved were fully informed of the contamination detected. The retailers affected withdrew all their potentially affected basil products. The UK FSA also advised consumers who may have bought the contaminated basil not to eat it (FSA, 2007). Full investigations that were undertaken in response revealed no further contaminated product (FSA, 2007; HPA, 2007b; Pezzoli et al., 2008). Previously in 2006 in Denmark, imported basil used to make pesto was also implicated in an outbreak of *S. Anatum* and enterotoxigenic *E. coli* associated with school dinners in Greater Copenhagen (Bagdonaite et al., 2006; Pakalniskiene et al., 2008). Food which is intended for human consumption must meet the general food safety requirements of European Union (EU) law; this also applies to food imported into the EU (EC, 2002a).

There are many examples of fresh vegetables and fruit in international trade causing human illness in Europe and beyond, and a large proportion have involved leafy green products or fresh herbs contaminated with various *Salmonella* spp. (Campbell et al., 2001; Doyle and Erickson, 2008; Little and Gillespie, 2008; Pezzoli et al., 2007). A small proportion of ready-to-eat fresh herbs in this study (0.5%) were contaminated with *Salmonella* spp.. This is lower than that found in two UK studies in London in 2006 (1.7%, imported and domestic herbs) and 2005 (13.1%, imported herbs), but this is still unacceptable. In Norway in 2005 and 2007, 28% and 15%, respectively, of imported fresh pre-cut herbs (basil, mint, coriander) from South East Asia were found to be contaminated with salmonella, and 18 different serotypes were detected (Norwegian Scientific Committee for Food Safety, 2008). Interestingly, an earlier Norwegian study of 230 domestic and imported fresh herbs in Norway during 1999 and 2001 failed to detect any salmonella (Johannessen et al., 2002). In the USA, a Food and Drug Administration (FDA) survey of domestic fresh produce in 2000 and 2001 (FDA, 2001) reported that 1.1% of fresh herbs (parsley, cilantro) were contaminated with *Salmonella* spp., whereas another FDA survey of imported fresh produce in 1999 (FDA, 2003) found 8.8% of fresh herb samples (cilantro, culantro, parsley) to be contaminated. The different detection rates of salmonella contamination reported in the studies might reflect differences in conditions during pre-, during and post-harvest operations.

E. coli is an indicator of faecal contamination, and is a common environmental bacterium that is found in soil and water (Beuchat, 1998). Vegetables therefore may easily become contaminated with these bacteria. However, levels of these bacteria in raw ready-to-eat vegetables should be kept to a minimum. In the case of obtaining unsatisfactory levels of *E.*

coli, the food business operator should improve production hygiene, and selection of raw materials (EC, 2007). For pre-cut herbs in the present study, 1.4% contained *E. coli* at $>10^3$ cfu/g and exceeded the process hygiene criteria within Regulation (EC) 2073/2005 (as amended) (EC, 2007). Overall, 6.7% of herbs contained *E. coli*, of which 3.6% were at $\geq 10^2$ cfu/g. In comparison, a greater proportion of imported fresh herbs tested in Norway in 2005 were found to be contaminated with *E. coli* at $>10^2$ cfu/g (35%) (Norwegian Scientific Committee for Food Safety, 2008).

Herbs that were pre-cut in this study contained over twice as much *E. coli* at $\geq 10^2$ cfu/g (4.1%; 95% CI: 3.4%-4.8%) as those sold in open containers (e.g. growing herbs in pots, 1.6%; 95% CI: 0.7%-2.5%) ($p=0.0006$). Herbs sold in pots that are grown in the UK and Europe tend to be propagated under controlled environments using a substrate that has less bacterial loading than soil and they are watered from the bottom to reduce splashing onto the leaves. Cut herbs are generally grown in soil worldwide, therefore there is an increased risk of contamination. The process of cutting may introduce additional contaminants, and the availability of moisture and nutrients on the cut surfaces creates conditions that favour microbial growth (Doyle and Erickson, 2008).

Escherichia coli is one of the dominant microorganisms present in human and animal faeces and has been used as a marker (index and indicator) organism for faecal contamination for decades. The use of *E. coli* as an indicator organism is based on the concept that its detection in food or water samples indirectly provides evidence that the sample has been contaminated with faecal material and that pathogenic organisms may also be present. The use of *E. coli* as an indicator organism has been challenged by a range of investigations, with some criticising its use, however no suitable substitute has been identified (Feng, 2001; Roberts and Greenwood, 2003). Spiking experiments of manure used for the cultivation of root and leaf vegetables, including carrot, radish and arugula (rocket) in the USA, identified similarity in the survival rates of salmonella and *E. coli* and led investigators to recommend the use of *E. coli* as an indicator organism for *S. enterica* (Natvig et al. 2002). In the study of fresh herbs presented here, a range of levels of *E. coli* were found to be present in salmonella positive samples, with 55.6% having an *E. coli* result of <20 cfu/g recorded (the limit of detection). These findings indicate that, in this instance, high levels of *E. coli* was not a reliable indicator for the presence of salmonella.

Most (77.4%) of the ready-to-eat fresh herbs in this study were stored or displayed above 8°C in the retail premises. These products should not be stored at temperatures that might result in a risk to health (Regulation (EC) No. 852/2004 (EC, 2004)) and, as a matter of best practice, should preferably be kept at or below 8°C during storage and display. There may be exemptions for tender leafed types of fresh herb, such as basil, where 12-15°C may be more appropriate to prevent chill damage.

Although 85% of packaged fresh herbs sampled in this study were labelled with instructions to 'wash before use', it is known that effective washing and decontamination of ready-to-eat vegetables is difficult (Seymour, 1999). Both packaged herbs with instructions to 'wash before use' and those with no such instructions contained *Salmonella* spp. (0.4% and 0.7%, respectively). Washing with potable water can reduce the microbial load, and a range of different agents is also available for disinfecting/sanitising fresh produce, although their efficacy is variable and none are able to ensure elimination of pathogens (Doyle and Erickson, 2008; EC, 2002b). Reduction of risk for human illness associated with raw produce, such as fresh herbs, cannot rely solely on the end consumer to wash the product before use. This would be better achieved through controlling points of potential contamination in the field, during harvesting, and during processing and distribution of fresh produce.

The fresh produce supply chain should remain vigilant in ensuring food safety controls are in place throughout, from grower to consumer. The UK Chilled Food Association (CFA) has, for example, addressed this issue by producing microbiological guidance for produce suppliers to chilled food manufacturers to help minimise microbial food safety hazards (CFA, 2007). Given the microbiological concerns raised in this study on fresh herbs, application of similar standards and approaches set out in industry guidelines for the herb sector could also help to minimise contamination and/or bacterial growth in these products.

Acknowledgements

The authors would like to thank the following people for their contribution to this study; staff in the Environmental Health Departments throughout the UK who collected samples for this study, staff in the HPA, HPA collaborating and other Official Food Control Laboratories who performed the microbiological examination of samples, staff in the Laboratory of Enteric Pathogens (HPA Centre for Infections) for characterising isolates of *Salmonella* spp., David Lock and Gemma Cantelo at LACORS for co-ordinating the participation of Environmental Health Officers and advice from the LACORS Food Examination Focus Group and Food Hygiene Focus Group, and the HPA Regional FWE Co-ordinators Forum for their advice in preparing the sampling protocols.

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ANNEX I: Participating Laboratories and Local Authority Liaison Groups in and number of samples.

Table I. Participating HPA and HPA collaborating laboratories and number of samples examined.

HPA Region	HPA/HPA Collaborating Laboratory	Number of samples
East	Chelmsford	302
	Norwich	97
East Midlands	Leicester	96
	Lincoln	84
London	London	185
South East	Ashford	121
	Haywards Heath	229
	WEMS	312
North East	Newcastle	202
North West	Carlisle	56
	Chester	311
	Preston	437
South West	Bristol	113
	Exeter	132
	Gloucester	53
	Plymouth	10
	Truro	51
West Midlands	Birmingham	78
	Coventry	103
	Shrewsbury	128
	Hereford	32
Yorkshire & the Humber	Leeds	163
	Sheffield	109
Total		3404

Table II. Other participating Official Food Control Laboratories in Wales, Scotland, Northern Ireland & England and number of samples examined.

Country	Laboratory	Number of samples
Wales	Bangor	39
	Cardiff	46
	Carmarthen	137
	Rhyl	36
Ireland	Belfast	51
Scotland	Edinburgh	43
England	Kings Lynn & Norfolk	4
Total		356

Table III. Participating Food Safety Liaison Groups and number of samples examined.

Local Authority Food Liaison Group	Number of Samples
Berkshire	114
Buckinghamshire	16
Cambridgeshire	61
Cheshire	127
Cornwall	51
Cumbria	56
Derbyshire	59
Devon	78
Dorset	21
Durham	54
East Sussex	56
Essex	219
Gloucestershire	68
Greater Manchester	163
Hampshire & Isle of Wight	95
Hants & IOW	6
Hereford & Worcester	51
Hertfordshire & Bedfordshire	69
Humberside/North Lincoln	85
Kent	121
Lancashire	274
Leicestershire	96
LFCG ^a NE Sector	23
LFCG NW Sector	32
LFCG SE Sector	10
LFCG SW Sector	35
Lincolnshire	49
Scottish Food Enforcement Liaison Committee (Lothian & Scottish Borders)	43
Merseyside	152
Norfolk	50
North Wales	107
North Yorkshire	38
Northamptonshire	43
Northern Ireland Food Liaison Group ^b	51
Northumberland	19
Nottinghamshire	28
Oxfordshire	71
Shropshire	74
Somerset	76
South East Wales	56
South West Wales	150
South/West Yorkshire	114
Suffolk	63
Surrey	107
Tees Valley	57
Tyne & Wear	55
Warwickshire	60
West Midlands	100
West of England	46
West Sussex	71
Wiltshire	40
Total	3760

^a London Food Co-ordinating Group

^b Northern Ireland Food Group consists of Eastern, Northern, Southern and Western Groups.

Laboratory details: Sample(s) received in laboratory..... (time) on (date)/...../.....
 Sample(s) received by.....
 Sample(s) received from.....
 Temperature on receipt °C
 Within the cool box is a temperature monitoring device used e.g. data logger : YES NO
 Sample(s) examined. (time) on (date)/...../.....

RESULTS

Recording results

Please record the results of count/g tests as **ACTUAL NUMBERS** in the appropriate box within the table. Only place ticks in the column headed (<20), i.e. the limit of detection for that test, and columns headed ND (Not Detected) and Detected.

Laboratory Sample No.....

	ND	Detected	<20	20-<10 ²	10 ² -<10 ³	10 ³ -<10 ⁴	10 ⁴ -<10 ⁵	10 ⁵ -<10 ⁶	10 ⁶ -<10 ⁷	≥10 ⁷
<i>Escherichia coli</i> /g										
<i>Salmonella</i> spp. 25/g*										

Microbiological Quality: Satisfactory Acceptable Unsatisfactory Unacceptable/Potentially hazardous

Regarding detection of *Salmonella* spp. please check the Unacceptable category above but NOTE that:

- *Salmonella* spp. detected in pre-cut fresh herbs exceeds food safety criteria for ready-to-eat foods placed on the market during their shelf-life and is thus deemed to be legally unsatisfactory (Regulation (EC) No. 2073/2005).
- *Salmonella* spp. detected in other fresh herbs are of unacceptable quality using published public health Guidelines and are also covered by Regulation (EC) No. 178/2002 (General Food Law Regulation)

Date *Salmonella* isolates sent to the Laboratory of Enteric Pathogens, HPA Centre for Infections or in Scotland to the Scottish Reference Laboratory (Stobhill Hospital Glasgow)

MICROBIOLOGISTS COMMENTS.....

Signature Date reported

WHERE POSSIBLE THE LABORATORY SHOULD MAKE AND RETAIN A PHOTOCOPY OF THE
 PRODUCT LABEL FOR FUTURE REFERENCE