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An assessment of the microbiological quality of lightly cooked food (including sous-vide) at the point of consumption in England

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SUMMARY

This observational study aims to investigate the microbiological quality of commercially prepared lightly cooked foods with a major component of food of animal origin and collected as would be served to a consumer. A total of 356 samples were collected from catering (92%), retail (7%) or producers (1%) and all were independent of known incidents of foodborne illness. Using standard methods, all samples were tested for: the presence of *Campylobacter* spp. and *Salmonella* spp. and enumerated for levels of, *Bacillus* spp. including *B. cereus, Clostridium perfringens, Listeria* spp. including *L. monocytogenes, Staphylococcus aureus, Escherichia coli*, Enterobacteriacea and aerobic colony count (ACC). Results were interpreted as unsatisfactory, borderline or satisfactory according to the Health Protection Agency guidelines for assessing the microbiological safety of ready-to-eat foods placed on the market. Amongst all samples, 70% were classified as satisfactory, 18% were borderline and 12% were of unsatisfactory microbiological quality. Amongst the unsatisfactory samples, six (2%) were potentially injurious to health due to the presence of: *Salmonella* spp. (one duck breast); *Campylobacter* spp. (two duck breast and one chicken liver pâté); *L. monocytogenes* at $4{\cdot}3 \times 10^3$ cfu (colony-forming units)/g (one duck confit with foie gras ballotin) and *C. perfringens* at $2{\cdot}5 \times 10^5$ cfu/g (one chicken liver pâté).

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The remaining unsatisfactory samples were due to high levels of indicator *E. coli*, Enterobacteriaceae or ACC.

Key words: Catering, food safety, lightly cooked food, liver, microbiological quality, poultry products, sous-vide.

INTRODUCTION

Lightly cooked foods were originally described by Sir Benjamin Thompson (Count Rumford) in the late 18th century, and this cooking method was redeveloped by American and French engineers in the mid-1960s as a more widespread commercial cooking method [1]. There are now different techniques for lightly cooking foods, which include either the modification of existing processes with reduced cooking times (e.g. undercooking or flash frying), mild heating such as the using a bain-marie, or the use of a completely different cooking method such as sous-vide. The sous-vide method involves the cooking of food for extended times in hermetically (vacuum) sealed containers at 'low' temperatures by immersion in a water bath, and in some instances, followed by storage under refrigeration prior to a further heat regeneration before consumption [1, 2]. Overall, lightly cooking methods can be used alone or in combination with other cooking methods and their use became more common in commercial cooking (especially for sous-vide) from the 1970s, particularly since there can be better consistency and moisture retention in the final product [1]. Sous-vide is also now available for use in domestic settings [3].

Lightly cooked foods encompass a wide range of cooking times and temperatures, and these can vary from minutes to several hours for sous-vide, and may involve temperatures between 40 and 60 °C [3]. After cooking and at the point of serving, products may be near sterile, or more often, either at a point where vegetative bacterial cells are destroyed but bacterial spores remain, or when both vegetative cells and bacterial spores remain. Examples of food cooked in these ways where vegetative cells are likely to survive are burgers served rare, rare duck meat (pink duck), liver parfait and liver pâtés.

There is some information on the survival of specific bacterial foodborne hazards through challenge studies using various sous-vide and other light cooking processes [3–8]. However, there are limited data to predict the effectiveness to kill and prevent the growth of bacterial foodborne pathogens at the lower cooking temperatures [9] or to verify how efficient these processes are in practice including in commercial settings.

The purpose of this observational study was to investigate the microbiological quality of commercially prepared lightly cooked foods as would be served to a consumer. Because of the types of foods associated with foodborne illness as well the increased likelihood of bacterial hazards occurring, this study focused on products with major components of animal origin.

METHODS

Sample collection

A total of 356 samples of ready-to-eat lightly cooked foods (as would be served to a consumer) were collected by sampling officers from 75 Environmental Health Departments in England during April to September 2011. Samples were collected from catering, retail or producers, and included a wide range of products (mostly with animal product-based ingredients) and different cooking methods. All samples were collected independent of any known incident of foodborne illness. Samples (of at least 100 g) were collected and transported in accordance with the Food Standards Agency Food Law Practice Guidance [10]. Information on premises and sample type was also collected by the sampling officer using a standardized study questionnaire.

Microbiological examination

Samples were transported at between 0 and 8 °C to Health Protection Agency (HPA) Food Water and Environmental Microbiology Laboratories in England based at Ashford, Birmingham, Bristol, London, Preston, Porton and York. Samples were microbiologically examined within 24 h of collection using standard methods, which comprised: the presence of both *Salmonella* spp. (ISO 6579:2002) and *Campylobacter* spp. (ISO 10272-1:2006); the presence and enumeration of *Listeria* spp., including *Listeria monocytogenes* (ISO

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Table 1. *Criteria for the interpretation of microbiology quality results [11]*

	cfu/g (except *Salmonella* and *Campylobacter* detected in 25 g)			
Microbiological parameter	Satisfactory	Borderline	Unsatisfactory	Unsatisfactory and potentially injurious to health
Bacillus spp. including *B. cereus*	$<10^3$	10^3–$\leqslant 10^5$	N/A	$>10^5$
Campylobacter spp.	Not detected	N/A	N/A	Detected
Clostridium perfringens	<10	10–10^4	N/A	$>10^4$
Listeria monocytogenes	<20	20–<100	N/A	$\geqslant 100$
Listeria species (not *monocytogenes*)	<20	20–<100	$\geqslant 100$	N/A[a]
Salmonella spp.	Not detected	N/A	N/A	Detected
Staphylococcus aureus and other coagulase-positive staphylococci	<20	20–$<10^4$	N/A	$\geqslant 10^4$
Escherichia coli	<20	20–100	$\geqslant 100$	N/A
Enterobacteriacea	$<10^2$	10^2–10^4	$>10^4$	N/A
Aerobic colony count (ACC)				
RTE Food category[a]				
2. Cooked – immediate consumption	$<10^3$	10^3–$<10^5$	$\geqslant 10^5$	N/A
3. Cook-chill – minimal handling	$<10^4$	10^4–$<10^7$	$\geqslant 10^7$	NA
5. Cook-chill – some handling	$<10^5$	10^5–$<10^7$	$\geqslant 10^{7b}$	NA
8. Cook-chill – vacuum packed	$<10^6$	10^6–$<10^8$	$\geqslant 10^{8b}$	NA

N/A, not applicable; cfu, colony-forming units.
[a] As defined in HPA, 2009 [11].
[b] Unsatisfactory if $\geqslant 10^7$ is predominantly gram negative or *Bacillus* spp. or $\geqslant 10^8$ if lactic acid bacteria.

11290-1:1996 and ISO 11290-2:1998); and enumeration of *Clostridium perfringens* (ISO 7937:2004), coagulase-positive staphylococci, including *Staphylococcus aureus* using (ISO 6888-1:1999), *Bacillus* spp., including *Bacillus cereus* (ISO 7932:2004), *Escherichia coli* (BS ISO 16649-2:2001), Enterobacteriaceae using (ISO 21528-2:2004) and Aerobic Colony Count (BS EN ISO 4833:2003). All presence/absence tests were performed on 25 g samples and the identification of isolates of *Campylobacter* spp., *C. perfringens, L. monocytogenes* and *Salmonella* spp. was performed in each of the individual laboratories as outlined in the standard methods above.

Microbiological results were interpreted according to the HPA guidelines for assessing the microbiological safety of ready-to-eat foods placed on the market [11] (Table 1) and, where relevant, using the EC Commission Regulation No. 2073 on the microbiological criteria for foodstuffs [12].

Confirmation of identity and typing of *Campylobacter* spp., *L. monocytogenes* and *Salmonella* spp.

Cultures were sent to the Public Health England (PHE) Gastrointestinal Bacteria Reference Unit (GBRU), for confirmation of identity and further characterization. Speciation was performed as described previously for *Campylobacter* spp. [13], *C. perfringens* [14], *L. monocytogenes* [15, 16] and *Salmonella* spp. [17, 18]. Cultures were further characterized as follows: *C. perfringens* enterotoxin gene detection by PCR [14]; *L. monocytogenes* by molecular serogrouping by PCR [19] and fluorescent amplified fragment length polymorphism (fAFLP) [20]; and *Salmonella* spp. by serotyping and phage-typing [21].

Statistical analysis

Descriptive and statistical analyses of the data were undertaken using Microsoft Excel. Relative proportions were compared using the Fisher's exact test. A probability value of <5% was defined as significant.

RESULTS

Amongst the total of 356 samples, 328 (92%) were from catering outlets (including restaurants, hotels or public houses), 24 (7%) were from retail establishments (e.g. delicatessens, farm-shops) and four (1%) were from producers. Sampling Officers were instructed

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Table 2. *Microbiological quality in relation to animal origin type in 356 ready-to-eat lightly cooked foods*

Main component of food derived from (no. of samples)	Number of samples (%)		
	Satisfactory	Borderline	Unsatisfactory
Total poultry (232)	162 (70)	38 (16)	32 (14)
Chicken (23)	19	2	2
Chicken liver (115)	74	23	18
Chicken and pigeon liver (2)	0	2	0
Duck (52)	43	4	5
Duck and/or goose liver (26)	16	4	6
Other poultry/game birds (10)	6	3	1
Eggs (4)	4	0	0
Total mammalian (106)	77 (73)	20 (19)	9 (8)
Lamb (30)	25	3	2
Lamb offal (4)	3[a]	0	1
Beef, veal and venison[b] (29)	19	5[a]	5
Calf or ox liver (10)	8	2	0
Pork (24)	18	6	0
Pork liver (3)	1	2	0
Rabbit including rabbit liver (4)	1	2	1
Mixed meats[c] (2)	2	0	0
Total fish (18)	10 (55)	5 (28)	3 (17)
All samples (356)	249 (70)	63 (18)	44 (12)

[a] *L. monocytogenes* detected in one of these samples.
[b] Beef (26), Veal (2) and Venison (1).
[c] Mixed ham and chicken (1) and mixed rabbit and ham (1).

to collect samples as they would be sold or served and 25 (9·8%: three beef; two duck; 12 lamb; four pork; two rabbit; one guiney-fowl and one quail) were collected from refrigerated storage and further reheating before serving may have been intended. A wide variety of dishes were sampled including lightly cooked poultry meats (e.g. duck breasts), liver of various species, red meats (e.g. steaks) and fish, pâtés, liver parfaits, terrines and smoked products. The major components in the products were: poultry meat, offal and eggs in 232 (65%); beef, ox or venison in 39 (11%); lamb in 34 (10%); pork in 27 (8%); rabbit in four (1%); meat of more than one mammalian species in two samples; and fish in 18 (5%; Table 2). It was not possible to collect temperature data for flash frying or bain-marie use; however, amongst the 115 samples cooked using sous-vide, temperatures of between 44 and >100 °C were recorded. Amongst those cooked at $\leqslant$50 °C, cooking times of between 10 and 50 min were applied.

Using the HPA Guidelines on microbiological quality (Table 1) [11], 44 (12%) of samples were of unsatisfactory microbiological quality, 63 (18%) were borderline and 249 (70%) were classified as of satisfactory microbiological quality (Table 2). Of the 44 unsatisfactory samples, six (2%) were classified as of unsatisfactory quality and potentially injurious to health, which related to the presence of *Campylobacter* spp. or *Salmonella* spp., an elevated count of either *L. monocytogenes* [$4{\cdot}3 \times 10^3$ cfu (colony-forming units)/g] or *C. perfringens* ($2{\cdot}5 \times 10^5$ cfu/g) (Table 3). The samples where either *Salmonella* spp. was detected or *L. monocytogenes* was recovered at >100 cfu/g did also not comply with microbiological criteria for meat preparations intended to be eaten cooked and ready-to-eat food, respectively, in EC Regulation No. 2073 [12].

A category of either borderline or unsatisfactory [11] was detected in 30% of the poultry ($n = 232$), 27% of the mammalian ($n = 106$) and 44% of the fish-based products ($n = 18$): the product groups where the highest proportion were borderline or unsatisfactory were either chicken liver (36%) or duck/goose liver (38%). The six samples that were of an unsatisfactory quality and potentially injurious to health were all derived from poultry, however, compared with samples derived from all other animal species, this was not significantly different (Fisher's exact test; $P > 0{\cdot}05$). Other samples of unsatisfactory microbiological quality were associated with high counts of

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Table 3. *Microbiological quality in relation to microbiological parameters of 356 lightly cooked foods*

Microbiological parameter	Number of samples		
	Satisfactory	Borderline	Unsatisfactory
Bacillus spp. including *B. cereus*	355	1	0
Campylobacter spp.	353	NA	3[a,b]
C. perfringens	355	0	1[b,c]
L. monocytogenes	355[d]	0	1[b,e]
Listeria species (not *L. monocytogenes*)	356[f]	0	0
Salmonella spp.	355	NA	1[b,g]
S. aureus	355	1	0
Escherichia coli	344	3	8
Enterobacteriaceae	326	8	22
ACC	320	11	25

NA, not applicable; ACC, total aerobic colony count.
[a] *Campylobacter* spp. isolates from two of the three samples were submitted for further characterization and both identified as *C. jejuni*.
[b] Potentially injurious to health.
[c] *C. perfringens* did not harbour enterotoxin gene.
[d] Two samples *L. monocytogenes* detected (by enrichment only)
[e] *L. monocytogenes* serotype1/2c fAFLP type IIVc.
[f] Three samples *Listeria* spp. detected at enrichment only (two *L. innocua* and one *L. welshimeri*).
[g] *Salmonella* spp. isolates were identified as *S.* Typhimurium DT8 (four isolates) and *S.* Typhimurium DT30 (one isolate).

Table 4. *Cooking method in relation to microbiological quality*

Cooking method	Number of samples (%)			
	Total	Satisfactory	Borderline	Unsatisfactory
Sous-vide only	34	16 (47)	8 (24)	10 (29)
Bain-marie only	55	29 (53)	11 (20)	15 (27)
Short-time frying (e.g. 'flash fry')	60	38 (63)	13 (22)	9 (15)
Sous-vide and additional heating (e.g. searing)	81	68 (84)	10 (12)	3 (4)
Short-time frying and additional heating (e.g. oven roasting)	47	37(79)	7 (15)	3 (6)
Oven roasted/oven cooked	34	29 (85)	3 (9)	2 (6)
Poached or smoked	9	6 (67)	2 (22)	1 (11)
Not described	36	26 (72)	9 (25)	1 (3)

E. coli, Enterobacteriaceae or aerobic colony count (ACC) (Table 3).

The cooking methods were described as using sous-vide only for 34 (10%), bain-marie only for 55 (15%), short time ('flash') frying for 60 (17%), sous-vide plus additional heating such as searing for 81 (23%), short-time frying plus additional heating such as roasting for 47 (13%), oven cooking alone for 34 (10%), poaching or smoking for 9 (2%), and was not described for the remaining 36 (10%) of samples (Table 4). For the different cooking methods, the highest proportion of samples of an unsatisfactory microbiological quality were for those prepared using sous-vide only (29%) followed by bain-marie (27%) and flash frying (15%; Table 4). When sous-vide was combined with other cooking methods there was a significant improvement in microbiological quality compared with sous-vide cooking only (Fisher's exact test, $P = 0{\cdot}0002$; Table 4). The majority of poultry products were subjected to sous-vide and bain-marie preparations only (Table 5).

Campylobacter spp. isolates from two of the three samples were submitted for further characterization and isolates from both duck breast samples were identified as *Campylobacter jejuni* (Table 6 and Table 7). Five *Salmonella* isolates from the sous-vide cooked

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Table 5. *Cooking method in relation to main food component*

Main component of food derived from	Number of samples						
	Sous-vide only	Bain-marie only	Short time frying (e.g. 'flash fry')	Sous-vide and additional heating (e.g. searing)	Short time frying and additional heating (e.g. oven roasting)	Oven roasted/ oven cooked	Poached or smoked
Chicken liver	1	46	22	2	17	9	0
Duck and/or goose liver	5	4	4	3	0	1	1
Duck	3	0	9	9	16	13	0
Chicken	2	1	0	16	0	4	0
Other poultry incl. game	1	0	3	4	1	0	1
Mixed pigeon/ chicken liver	1	1	0	0	0	0	0
Eggs	0	0	0	0	0	0	2
Beef and veal	3	1	8	9	6	1	0
Lamb	6	0	1	20	2	1	0
Rabbit/rabbit liver	0	1	0	2	0	1	0
Lamb offal	0	0	3	1	0	0	0
Pork	4	0	1	13	1	3	2
Calf/ox liver	0	0	7	0	3	0	0
Pig liver	0	1	0	0	0	1	0
Fish	8	0	2	2	1	0	3
Mixed meats	0	0	0	0	0	0	0

duck breast were further characterized and identified as *S.* Typhimurium definitive phage type (DT) 8 (four isolates) and *S.* Typhimurium DT30 (one isolate). Two *L. monocytogenes* isolates from the sous-vide cooked duck confit-foie gras ballotine were both identified as *L. monocytogenes* serotype1/2c fAFLP type IIVc 17a. None of five *C. perfringens* isolates from the chicken liver pate examined harboured the enterotoxin gene (Table 6 and Table 7).

DISCUSSION

The study has investigated the microbiological quality of lightly cooked foods as they would be served to the consumer and prepared using a range of different cooking practices. It is important to understand the ability of foodborne pathogens to survive such cooking processes and how these processes are actually used. This information has implications for the risk associated with consuming such foods. Despite the increasing use of lightly cooking practices, there are no comparative data from other similar studies at this stage of the food chain. Although microbiological testing of final product will not assure food safety, it is important to verify that adequate food safety management systems are in place.

In this study, a total of 356 lightly cooked food samples were tested, and this is part of a continuing programme of PHE national co-ordinated food studies [22–26]. This programme involves two to three studies per year and relies on the close working relationship with Environmental Health Departments throughout England to carry out the sampling as part of their routine monitoring. This approach allows sampling officers some flexibility to investigate premises and sample the product types that occur in their local food businesses, rather than being prescriptive about the numbers of each sample type to collect. While the sampling strategies are not precisely defined, the study described here presents the results of over 350 samples collected from across all areas of England and throughout a 6-month time period.

Using the HPA Guidelines for ready-to-eat foods [11] a relatively high proportion, of foods tested in this study were either of borderline quality (18%) or unsatisfactory (12%) microbiological quality with 2% categorized as unsatisfactory and potentially injurious to health. Three of the six unsatisfactory and

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Table 6. *Cooking method and food type for samples of unsatisfactory/potentially injurious to health microbiological quality*

Main food component	Cooking method	Pathogen detected cfu/g except *Salmonella* and *Campylobacter* detected in 25 g	Other unsatisfactory (U) or borderline (B) test results (cfu/g)
Duck breast	Flash fried (to order; served 'pink')	*Campylobacter jejuni*	ACC, $5{\cdot}3 \times 10^4$ (B)
	Flash fried followed by oven roasting (4–5 min)	*C. jejuni*	ACC, $2{\cdot}6 \times 10^3$ (B)
	Sous-vide cooked (1 h and 20 min at 54 °C) and then refrigerated (to be consumed with or without further cooking)	*Salmonella* Typhimurium (DT8 and DT30)	ACC, $1{\cdot}6 \times 10^4$ (B)
Chicken liver	Pâté cooked in bain-marie (no temperature prescribed)	*Campylobacter* spp. (isolate not characterized further)	ACC, $1{\cdot}7 \times 10^7$ (U) *Escherichia coli* $3{\cdot}8 \times 10^2$ (U) Enterobacteriaceae $1{\cdot}5 \times 10^4$ (U)
	Chicken liver pâté; Poached in water. Subsequently frozen or stored chilled for up to 3 days	*C. perfringens* $2{\cdot}5 \times 10^5$	ACC, 4×10^8 (U) *Staphylococcus aureus* $6{\cdot}6 \times 10^2$ (B)
Duck liver	Duck confit-foie gras ballotine. Sous-vide cooked (12 h at 82·5 °C). Chilled and kept at 2 °C up to 5 days	*L. monocytogenes* $4{\cdot}0 \times 10^3$ cfu/g (serotype 1/2c, fAFLP type VIIc17a)	Enterobacteriaceae 5×10^4 (U) ACC, $1{\cdot}3 \times 10^8$ (U)

ACC, aerobic colony count; B, borderline; cfu, colony-forming units; DT, definitive phage type; fAFLP, fluorescent amplified fragment length polymorphism; U, unsatisfactory.

potentially injurious to health samples also had unsatisfactory results for indicator bacteria. The reasons for the potentially hazardous results in these products may relate to undercooking (e.g. for the flash-fried duck breasts) but post cooking cross-contamination could also be a factor. The high levels of *C. perfringens* may reflect the addition of herbs and spices which, in combination with inadequate cooling as well as poor temperature control, can lead to growth of the bacterium.

During this study no human illness investigations were linked to the *Salmonella, Campylobacter* or *L. monocytogenes* isolates detected; however, the results of this survey has shown that products prepared by light cooking methods can be contaminated with pathogens, which is unacceptable. Amongst all the food types, the risk identified in this study was the highest for poultry-derived products, although too few bovine, ovine offal or fish samples were tested to make meaningful comparison with these products.

The results from this study are in contrast to the microbiological quality reported in other recent studies of ready-to-eat foods tested in England where a much lower proportion of results were interpreted as of unsatisfactory/potentially injurious microbiological quality [22–26]. This may reflect the types of foods sampled, e.g. studies, sampling herbs, fruits or bean-sprouts or, if meat containing, adequately cooked ready-to-eat foods, may be less likely to result in detection of hazardous bacteria. A recent study in 2012–2013 of 870 samples of pâté on retail sale and from catering in England found only 8% of samples as unsatisfactory and of these two samples (0·2%) were deemed of a potentially injurious to health microbiological quality [one with *B. cereus* ($2{\cdot}6 \times 10^5$ cfu/g) and one with *L. monocytogenes* ($2{\cdot}9 \times 10^3$ cfu/g)]. Amongst the unsatisfactory samples there were no *Salmonella* spp. or *Campylobacter* spp. detected, and no elevated levels of *C. perfringens* [26].

The main ingredients in the majority of foods examined in this study were of animal origin, and those of poorest microbiological quality contained poultry liver. It is well recognized that raw poultry livers frequently contain pathogens. Over 70% of UK retail chickens are contaminated with campylobacters and levels can exceed 1 million cells per whole fresh chicken [27, 28]. Chicken livers are often contaminated with campylobacters on the surface but campylobacters may also be present inside the tissues: raw poultry livers have been shown to contain up to 72 000 cfu of campylobacters per liver [29]. A review of recipes for pâté manufacturing identified procedures likely to eliminate, or at least reduce, the presence of *Campylobacter*, i.e. washing livers with organic acids,

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Table 7. *Unsatisfactory microbiological quality results in relation to food type*

Food derived from	Microbiological reason for unsatisfactory results (no. of samples with unsatisfactory result)
Duck	*Campylobacter* spp. (2*) *Salmonella* spp. (1*) ACC (2)
Chicken liver	*Campylobacter* spp., *Escherichia coli*, Enterobacteriaceae and ACC (1*) *C. perfringens* and ACC (1*) *E. coli* and Enterobacteriaceae (2) *E.coli* (2) Enterobacteriaceae and ACC (2) Enterobacteriaceae (7) ACC (3)
Duck and/or goose liver	*L. monocytogenes*, Enterobacteriacea and ACC (1*) Enterobacteriaceae and ACC (1) *E. coli* and ACC (1) *E. coli* (1) ACC (2)
Beef	Enterobacteriaceae (2) ACC (3)
Fish	*E. coli* (1) Enterobacteriaceae and ACC (1) ACC (1)
Chicken	Enterobacteriaceae and ACC (2)
Lamb	Enterobacteriaceae and ACC (1) ACC (1)
Rabbit	*E. coli* and Enterobacteriaceae (1)
Lamb offal	ACC (1)
Game	Enterobacteriaceae and ACC (1)

* samples deemed unsatisfactory and potentially injurious to health; ACC, total aerobic colony count.

freeze thawing and flambé in alcohol [30] and the Food Standards Agency (FSA) has provided advice including a liver pâté recipe 'for caterers that's free from the bacteria campylobacter' [31]. At the time of writing (2016) efforts by the poultry industry have shown some reduction in the levels of *Campylobacter* contamination on the surface of chickens at retail [32]. However, a study in 2015 showed a tendency for both chefs and the general public to undercook liver [33]. Although the highest numbers of campylobacteriosis outbreaks in England were reported in 2010 (where there was good evidence for inadequate cooking at the point of production in catering settings [34, 35]), these have continued to be reported each year up to the time of writing in 2016 (PHE unpublished data) demonstrating a continuing public health risk.

This study highlights public health risks associated with the consumption of lightly cooked foods especially when derived from poultry and demonstrates that, in 2011, some Food Business Operators do not have an adequate Food Safety Management System in place. Nevertheless, if cooking processes are properly applied (together with adequate storage and prevention of cross-contamination), evidence from elsewhere shows that the microbiological risks, at least from sous-vide processed food, can be controlled to an acceptable level [36].

The UK FSA has recently commenced discussions considering 'risky' foods which were defined as 'foods where risks per serving are significant' [37]. While such foods are normally understood to include oysters consumed raw, raw drinking milk and rare burgers, undercooked poultry livers could also be classified as belonging to this category. The standing advice from the UK Advisory Committee on the Microbiological Safety of Food for cooking burgers is that they should be cooked thoroughly, i.e. reach a core temperature of 70 °C for 2 min (or equivalent) and this delivers a significant pathogen reduction [38]. However, for rare burgers it was proposed that, 'it is not so unacceptable as to justify removing the adult consumer's right to choose to eat it, provided a validated and verified food safety management system is applied, including in each case a set of controls'. The controls should include a combination of source controls, evidence that controls for microbiological hazards have been validated and their effective application has been validated, pathway management and consumer advice. On the basis of the observations here, some of the products examined during this study would be of a similar level of risk to that described above as 'risky' foods, and the application of similar mitigation steps would be applicable.

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DECLARATION OF INTERESTS

None.

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