ADVISORY COMMITTEE ON THE MICROBIOLOGICAL SAFETY OF FOOD

MODELLING THE IMPACT OF POTENTIAL INTERVENTIONS THROUGHOUT THE SUPPLY CHAIN TO REDUCE THE RISK OF *E COLI* O157 INFECTION FROM RARE BURGERS

Introduction

1. Following the 9th September 2015 Board meeting the FSA was asked to identify potential interventions that could be employed throughout the supply chain that would reduce the risk of *E coli* O157 from rare burgers to a level similar to that of burgers that were well done. This note sets out the approach undertaken to achieve this aim and the accompanying results.

2. During discussion of the rare burgers paper at the committee's meeting in January 2016 three members of ACMSF (David McDowell, Gary Barker and Roy Betts) offered to assist the FSA with this work and they have provided advice and comments on our approach and analysis which has been facilitated by a series of three teleconferences.

Approach

<u>Identifying potential interventions</u>

3. The first phase of this work was to identify a list of possible interventions to consider. This was done by consulting scientific research papers, FSA funded research and expert knowledge throughout the Agency, particularly from Operations and Policy staff. Colleagues from Food Standards Scotland were also consulted for their suggestions and comments.

4. A list of 38 interventions was identified and these were then assessed in more detail. From this long list four interventions were identified where current evidence was considered sufficient to evaluate further. These were:

   - Bunging (Anal sealing of carcases)
   - Lactic acid
   - Steam-vacuum
   - Steam pasteurization

Further descriptions of these four interventions can be found in Annex A

The reasons for other interventions being rejected can be grouped as shown in Table 1.

Table 1: Reasons for interventions being rejected

Grouping	Number
Interventions that could be considered good practice and of benefit, but for which evidence of significant reduction in risk was limited	4
Interventions where evidence of a beneficial impact was inconclusive	2
Interventions which are really business as usual	4
Interventions which might have potential but need further development	9
Interventions not currently legal in UK	7
Interventions that were considered unfeasible for a variety of other reasons	8
Total	34

5. These assessments were discussed and agreed internally and then with the three ACMSF members at the first of the teleconferences. A full list of the 38 interventions considered can be found in Annex B.

<u>Baseline risks from different size burgers with different cooking preferences</u>

6. The September 2015 FSA Board paper[1] used the results of studies conducted by the Animal and Plant Health Agency (APHA) and the National Institute for Public Health and the Environment (RIVM) to provide estimates of the potential risks from the cooking preferences of rare, medium and well-done burgers (these had mean temperatures of 54.4, 62.7 and 68.3^{o}C respectively). For each of these cooking preferences small, standard and gourmet burgers were considered, these being defined as shown in Table 2 below.

Table 2: Summary of the characteristics of the burgers considered within the model

Burger	Height	Diameter	Weight
Small	1 cm	8.5 cm	85 g
Standard	2.5 cm	8.5 cm	113 g
Gourmet	5 cm	8.5 cm	227 g

7. The results of this work were presented as the risk per 100,000 servings for each burger type and cooking method combination.

8. While these results helped to show the relative risk for each combination they were more problematic when used to estimate the overall number of cases. As with any model, there were uncertainties in the modelling, particularly with how the different levels of contamination would affect the numbers of human cases. This meant that when these risks per 100,000 servings were scaled up to get annual aggregated cases (using estimates of burger consumption) the number of cases from all burgers (not just rare – indeed based on these estimates up to

[1] http://www.food.gov.uk/sites/default/files/fsa150904.pdf

80% of illnesses related to burgers may be from those that are well-done) was more than a factor of 100 times greater than those reported as laboratory confirmed cases of *E.coli* O157[2]. While there may be some under-reporting, given the severity of the illness this is unlikely to be large. Furthermore the confirmed cases include illnesses caused by other sources, both food and non-food, so the number of cases relating to burgers is likely to be a small subset[3]. PHE enhanced surveillance of sporadic STEC infections in England since 2009 has not highlighted burgers as a major risk factor.

9. Given this over-estimating of aggregated cases it was decided to re-position the results to show relative risk, rather than risk per 100,000 servings. This does not change the overall results or conclusion drawn from the models that was discussed in the Board paper, but focuses the discussion on relative risk rather than a possibly overstated aggregate risk.

10. To estimate relative risk, we need to have something that it is relative to. This needs to be something that is regarded as having an acceptable risk. Therefore we have compared the risk from rare burgers to that of a well-done small burger using the result form the quantitative risk assessment model developed by Animal and Plant Health Agency (APHA). This was the model used in the previous APHA (Berriman *et al*., 2014) and RIVM studies (Swart et al., 2015)[4]. The relative risks for each burger size/cooking preference compared to such a burger are given below. Also provided are the relative risks for a 4 and 6 log reduction at cooking for each burger size to be consistent with the results provided in the board paper. Findings are shown in Table 3

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[2] The number of confirmed laboratory reports are provided by Public Health England, Public Health Wales, Health Protection Scotland and Public Health Agency Northern Ireland,

[3] Based on results from the Second Study of Infectious Intestinal Disease (IID2) in the Community (Tam *et al.*, 2012) and the Costed extension to the Second Study of Infectious Intestinal Disease in the Community (IID2 Extension) (Tam et al., , 2014), we estimate that 53% of cases of *E.coli* O157 are foodborne (95% credible intervals 34% to 71%), while based on foodborne outbreaks between 2009 and 2013, only 16%[3] were attributed to burgers (not necessarily rare).

[4] This model is a Monte Carlo simulation and is developed in a software package called @risk, which is an add-in for MS Excel.

Table 3: Relative risk of *E.coli* O157 infection from different burger sizes and cooking preferences relative to a small well-done burger where the risk is 1.0

Burger	Log reduction from cooking	Relative risk to small well done burger - corrected model / baseline[5]
Small: Rare	0.2	1.2
Small: Medium	0.3	1.1
Small: Well-done	**0.3**	**1.0**
Small: 4 log reduction	4.0	0.4
Small: 6 log reduction	6.0	0.2
Standard: Rare	0.5	1.2
Standard: Medium	1.1	1.1
Standard: Well-done	4.1	0.4
Standard: 4 log reduction	4.0	0.5
Standard: 6 log reduction	6.0	0.2
Gourmet: Rare	0.8	2.1
Gourmet: Medium	6.5	0.2
Gourmet: Well-done	9.0	0.1
Gourmet: 4 log reduction	4.0	0.8
Gourmet: 6 log reduction	6.0	0.3

Estimating the impact of the interventions

11. The next stage was to model the extent to which the four interventions identified above reduced the risk of *E. coli* O157 infection from rare burgers.

12. For each of these interventions there is at least one research paper (see table 6 for source) where a reduction in contamination levels had been observed and figures for this reduction estimated.

13. To estimate the impact of these interventions, in terms of risk to humans at point of consumption, we adapted the APHA model to include the distributions of the reductions in *E. coli* and *E. coli* K12 (These were used as a proxy for *E. coli* O157, where this was not tested for in the research) described in the research papers.

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Results

14. For Lactic Acid and Steam Vacuum, there was more than one set of results available from different papers, so these were modelled separately. Having done some preliminary modelling, and discussed with the three ACMSF members, two of the interventions were rejected for the following reasons

    - **Bunging** – the research is based on a small study and only provides minimal results. Also the study was on sheep rather than cattle. When the data is used in the model, the outputs do not appear credible, in that all contamination is virtually eliminated. That doesn't mean Bunging would not be a useful intervention, but more comprehensive research on cattle would be required before it can be considered in the model.

    - **Steam Vacuum** – appears to be effective. However, the research is based on the section of the carcase that has been targeted. In practice this intervention would be reliant on spotting visible contamination and the diligence of the user and so there would be no guarantee that all contamination had been removed.

15. This leaves lactic acid and steam pasteurisation. Table 4 below shows that if either of these interventions is applied then the relative risk from all burger size/cooking preference combination is less (or the same in one case) than a small well-done burger with no such intervention. In addition, should a 4 log reduction at cooking be achievable then the relative risks are similar to those for a 6 log reduction at cooking without the interventions as shown in Table 3.

Table 4: The relative risk for rare and medium burgers after intervention: Small well-done burger relative risk is 1.0

Intervention	Lactic Acid 1 (1.6 - 2.6%, 43 to 60C)	Lactic Acid 2 (5%, 25C)	Lactic Acid 3 (1%, 60C)	Steam pasteurization
Log reduction from intervention	0.61 (0.04 - 1.19) reduction on E coli (Triangular distribution)	0.9 (+-0.2) reduction on E coli O157 (Uniform distribution)	1.02 reduction on E coli K12 (Fixed value)	0.39 (0.19 - 0.59) reduction on E coli (Triangular distribution)
Source	Greig *et al* (2012)	Fouladkhah *et al* (2012)	Fisher et al.(2008)	Greig *et al* (2012)
		Relative risk		
Small: Rare	0.5	0.3	0.2	0.6
Small: Medium	0.4	0.2	0.2	0.6
Small: 4 log reduction	0.1	0.1	0.1	0.2
Standard: Rare	0.5	0.3	0.3	0.6
Standard: Medium	0.4	0.3	0.2	0.5
Standard: 4 log reduction	0.2	0.1	0.1	0.3
Gourmet: Rare	0.8	0.6	0.5	1.0
Gourmet: Medium	0.1	0.1	0.1	0.2
Gourmet: 4 log reduction	0.4	0.2	0.2	0.4

ACTION

16. ACMSF members are invited to comment:
   - On the approach taken to this work and the findings presented in the paper.
   - Whether the committee agrees that the relative risks for burgers (small, standard or gourmet) made using untreated carcases and cooked to achieve a 6 log reduction of E.coli O157 are comparable to those for burgers made using carcases given a lactic acid or stream pasteurisation treatment and cooked to achieve a 4 log reduction in E.coli O157.

References

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Bunging
The process of bunging reduces faecal contamination by cutting around the cow's anus, placing a bag over the rectum and securing it in place with an elastic band or similar. This is done to prevent the need to cut the intestines which would introduce faecal matter inside the body cavity and thus contaminate the meat.

Lactic Acid
Lactic acid is a naturally occurring component of (beef) meat and so it is unlikely to form degradation or reaction products that do not occur naturally in meat. Lactic acid may be used to wash the entire carcases or half-carcases or quarters of meat from domestic bovine animals at slaughterhouse. Lactic acid solutions must not be applied to carcases with visible faecal contamination. The application of lactic acid solutions must not result in any irreversible physical modification of the meat. EFSA have concluded that treatments with lactic acid provide a significant reduction of microbiological contamination compared to no treatment or to treatment with potable water and that it is unlikely that such treatments would contribute to the development of microbial resistance.

Steam-Vacuum
Steam-vacuum uses steam to loosen contamination and kill bacteria, followed by application of a vacuum to remove contaminants. The effectiveness of steam vacuum depends on the diligence of the user. It is only useful when applied to specific areas of the carcass that are visibly contaminated and it would not be practical to vacuum the whole carcass. It can be used to remove visible contamination from carcasses if it can be shown to be an alternative/equivalent method to knife trimming provided that the tool is used for accidental contamination of carcases not used as a substitute to poor practices.

Steam Pasteurization
Similar to Steam-Vacuum, steam pasteurisation is a fast method of treating carcasses but it principally kills harmful organisms rather than removes them. Steam has advantages over the use of hot water due to the potential energy released when steam condenses, achieving a more rapid rise in the surface temperature of the meat. Generally the process should allow the temperature to reach at least 90°C for a sufficient time to achieve bacterial reduction, this is then followed by rapid cooling.

Annex B

List of interventions considered in relation to reducing VTEC O157 in rare burgers

Interventions that were modelled

1. Bunging
2. Steam-vacuum
3. Lactic Acid
4. Steam pasteurization

Interventions that are considered good practice and of benefit, but for which evidence of significant reduction in risk was limited

5. Hide/pelt removal method
6. Cleaning and disinfection of lairage-to-stunning areas in abattoirs
7. Shaving the hair in cutting areas
8. Use of temperature controlled equipment when mincing/mixing meat for this purpose

Interventions where evidence of a beneficial impact was inconclusive

9. Ultra-clean air
10. Oesophageal sealing (usually called rodding)

Interventions which are really business as usual

11. Carcase trimming - cutting off visible contamination
12. Pressure wash of the slaughterhouse
13. Proprietary sanitiser workers
14. Cold temperatures when preparing minced meat at approved premises

Interventions which might have long term potential but need further development

15. Carcase trimming - cutting off non visible contamination
16. Identify super shedding cattle
17. High pressure chamber
18. Final carcass wash
19. Blast air chillers
20. Naked gas flame treatment on hide
21. Hot air gun treatment on hide
22. Atmospheric Steam treatment on hide
23. Hot water spray treatment on hide

Interventions not currently legal in UK

24. Cetylpyridinium chloride
25. Hydrogen peroxide
26. Acidified sodium chlorite (ASC)
27. CA95 sanitiser and degreaser
28. Visual only inspections
29. Irradiation
30. Age limit on meat for slaughter post slaughter

Interventions that were considered infeasible for other reasons

31. Dry-aged chill
32. Feed withdrawal/wet feed/dry feed prior to slaughter
33. Removal of adipose before mincing
34. Selected Cutting
35. Probiotics
36. SRP Vaccine
37. Type III protein vaccine
38. Cleaning equipment with chemicals