R&D REPORT NO. 216

Reducing salt levels in foods

Preliminary observations on the effect of salt on the predicted growth of selected micro-organisms in meat products

2005

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SUMMARY

It has been widely reported that the consumption of excess levels of salt through the diet can have an adverse effect on human health. Various studies have considered the effects of increased levels of salt in foods and have linked high salt intake to various forms of cardiovascular illness.

In 2004, in response to this, the UK Food Standards Agency began a campaign to warn consumers over the potential adverse effects of consuming high levels of salt and additionally began working with the food industry to reduce the amount of salt in processed foods.

It is however important to understand that salt is not only added to foods to achieve particular positive organoleptic effects, it is also a powerful antimicrobial and has been used for many centuries to increase the shelf life and safety of food products.

This report only considers the potential microbiological effects of reducing salt levels in food products (primarily meat products have been given as examples). It does not cover, and is not intended to cover, the positive public health benefits of reducing salt levels in foods. It is believed that the beneficial effects of reducing salt, i.e. the reported positive public health effects due to reduction in cardiovascular illness, must be balanced against any potential increases in cases of food poisoning. This is best done by way of a Risk Assessment by experts in public health, nutrition and microbiology, who could weigh the available information and evidence, and come to a scientific conclusion on the relative risks of a salt reduction strategy.

This report details work done with predictive microbiological techniques to assess the effects of changes in salt level proposed in ham, bacon, sausages, burgers and meat pies, on the growth of key microbial pathogens in these products. These products have been picked as examples as they tend to be shorter shelf life chilled products, that may on occasion contain the pathogen groups listed below.

Results show that the changes to salt level will affect product microbiology by making products containing lower salt levels less able to resist microbial growth. The magnitude of the effect is dependent on the level of salt reduction and the microorganism concerned. Smaller reductions have less effect on microbial growth than do greater reductions. Salt tolerant organisms such as *Staphylococcus aureus* and *Listeria monocytogenes* are affected to a lesser degree than salt intolerant organisms such as *Salmonella, Escherichia coli* O157 and psychrotrophic *Clostridium botulinum*.

However, the results do clearly show that any reduction in salt level in meat products can increase the risks associated with microbiological growth. Food manufacturers should not consider any change in salt level before a suitable risk assessment of the effects of those changes has been done and the HACCP plan for the product checked and amended. A concern must be raised as to the ability of smaller food manufacturers to understand the microbiological implications of lowering salt levels, and to implement suitable investigations into possible increased microbiological risk associated with reduced salt levels.

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1. INTRODUCTION

With concerns over the effects of salt (NaCl) on cardiovascular illness in the UK, the UK Food Standards Agency has recently published some guidance on lower levels of salt that should be incorporated into a number of different food products.

Salt is incorporated into foods for a number of reasons, principally:

(1) Organoleptic – it changes the flavour profile of many foods.

(2) Technical – for example, there is evidence that it may change protein structure within a food (see Appendix 1).

(3) Microbiological – salt is antimicrobial and has a key role to play in many foods, in reducing or eliminating microbial growth. It will also work in synergy with other preserving factors to increase the stability and safety of foods by inhibiting microbial growth.

This report has examined the use of predictive microbiological techniques to assess the effects of changing salt levels on the microbiological stability and safety of meat products.

2. PRODUCT TYPES AND SALT CONCENTRATIONS

The UK Scientific Advisory Committee on Nutrition (SACN) report on salt and health was published on 15th May 2003 (FSA, 2003). It recommended daily target average salt intakes for age ranges within the population:

TABLE 1
DAILY TARGET SALT INTAKES AS RECOMMENDED BY SACN

Age	Target average salt intake (g/day)
0 - 6 months	<1
7 - 12 months	1
1 - 3 years	2
4 - 6 years	3
7 - 10 years	5
11 - 14 years	6
15 and older	6

The report noted that 15% to 20% of total dietary sodium intake is from discretionary sources (i.e. the addition of salt by the consumer during cooking or at the table), whilst 65% to 70% comes from the consumption of manufactured foods. The main sources of sodium in the diet come from cereals and cereal products which provide approximately 40% of the average intake, followed by meat and meat products, which contribute around 21%.

The SCAN report notes that current salt intakes for adults are at an average level of 9g/day, whilst those of younger age groups are lower.

TABLE 2
AVERAGE SALT INTAKES PER DAY

Age (years)	Average salt intake g/day
4 - 6	5.0
7 - 10	5.8
11 - 14	6.3
15 - 18	7.0
18+	9.0

If the intake values in Table 1 are to be met, there is a requirement to reduce salt in prepared foods and educate consumers on their responsibilities in exercising consumer choice, picking foods that give them a balanced diet and reducing their use of salt during cooking or at the table. The FSA has produced models of salt reduction that give target average sodium reduction levels for a range of prepared food products. The first of these models was launched in October 2003 (FSA 2003[2]), and has since been updated in February 2005 (FSA 2005). Table 3 details the target sodium reduction values given in the FSA model (2005 version) for each food group listed.

TABLE 3
SALT REDUCTION MODEL
TARGET SODIUM REDUCTION LEVELS

Food Group	Current Sodium Level (mg/100g)	Proposed Sodium Level (mg/100g)	Current Salt Level (% NaCl)	Proposed Salt Level (% NaCl)	% Reduction
Pasta - excluding ready meals	87	78	0.21	0.19	10
Rice	97	87	0.24	0.21	10
Pizza	600	300	1.50	0.75	50
Other cereals	441	300	1.10	0.75	32
White bread	476	350	1.19	0.87	26
Wholemeal bread	487	350	1.21	0.87	28
Brown bread	443	350	1.10	0.87	21
Other bread	601	350	1.50	0.87	42
Bought sandwiches	500	350	1.25	0.87	30
Breakfast cereal	466	300	1.16	0.75	36
Biscuits	367	250	0.91	0.62	32
Buns, cakes, pastries, fruit pies	284	200	0.71	0.50	30
Puddings, excluding processed puddings	144	144	0.36	0.36	0
Processed puddings	92	80	0.23	0.20	13
Milk and cream	43	43	0.10	0.10	0
Processed milk products	82	82	0.20	0.20	0
Fromage frais and yoghurt	61	61	0.15	0.15	0
Ice cream and diary desserts	64	64	0.16	0.16	0
Cheese	700	500	1.75	1.25	29
Homemade egg-based dishes	259	259	0.64	0.64	0
Quiche, manufactured	550	250	1.37	0.62	55

Food Group	Current Sodium Level (mg/100g)	Proposed Sodium Level (mg/100g)	Current Salt Level (% NaCl)	Proposed Salt Level (% NaCl)	% Reduction
Other processed egg products	410	300	1.02	0.75	27
Fat spreads	726	400	1.18	1.00	45
Bacon and ham	1491	750	3.72	1.87	50
Homemade meat dishes	163	163	0.40	0.47	0
Meat roll/sliced meat (excluding bacon/ham)	848	450	2.12	1.12	47
Other processed meat	823	450	2.05	1.12	45
Burgers, kebabs	503	300	1.25	0.75	40
Sausages	962	550	2.40	1.37	43
Meat pies	465	300	1.16	0.75	35
Homemade fish products	286	286	0.71	0.71	0
Canned fish	343	300	0.85	0.75	12
Other processed fish products	896	650	2.24	1.62	27
Vegetables and homemade vegetable dishes	37	37	0.09	0.09	0
Canned vegetables	256	50	0.64	0.12	81
Processed vegetable-based products	393	260	0.98	0.65	34
Baked beans	549	350	1.37	0.87	36
Potatoes excluding processed potato products	15	15	0.03	0.03	0
Chips (not homemade)	35	35	0.08	0.08	0
Other processed potato products	249	100	0.62	0.25	60
Crisps and snacks	909	550	0.27	1.37	40
Fruit	8	8	0.02	0.02	0

Food Group	Current Sodium Level (mg/100g)	Proposed Sodium Level (mg/100g)	Current Salt Level (% NaCl)	Proposed Salt Level (% NaCl)	% Reduction
Nuts and seeds	252	252	0.63	0.63	0
Sugar, preserves and confectionery	57	57	0.14	0.14	0
Drinks	3	3	0.007	0.007	0
Dry beverages	156	50	0.39	0.12	68
Miscellaneous (soup, gravy, stuffing etc., all homemade)	279	250	0.69	0.62	10
Soup retail	440	200	1.1	0.50	55
Cook-in pasta and sauce	627	250	1.56	0.62	60
Table sauces	914	600	2.28	1.5	34
Ready meals - meat-based	400	250	1	0.62	38
Meal centre meat-based (e.g. coated meat)	461	350	1.15	0.87	24
Ready meals, fish-based	300	200	0.75	0.50	33
Meal centre fish based (e.g. fish fingers)	430	250	1.07	0.62	42
Ready meals, vegetable based	300	200	0.75	0.50	33
Meal centre vegetable-based (coated veg products)	260	200	0.65	0.50	23
Ready meals, pasta-based	326	250	0.81	0.62	23
Meal centre pasta based (stuffed pasta)	128	100	0.32	0.25	22
Take away meat based	386	250	0.96	0.62	35
Take away fish	248	200	0.62	0.50	19

Food Group	Current Sodium Level (mg/100g)	Proposed Sodium Level (mg/100g)	Current Salt Level (% NaCl)	Proposed Salt Level (% NaCl)	% Reduction
Take away vegetable/potato	115	200	0.28	0.50	-74

It should be noted that in publications on salt in foods, the terms salt level and sodium level can sometimes appear synonymous. The two terms, however, are very different. Salt is sodium chloride and therefore is made up of both sodium and chlorine ions, whilst sodium is solely sodium. By law, food labels have to contain levels of sodium (not salt); therefore, to establish the level of salt in a food from a sodium level, a small calculation must be done. It is usually taken that multiplying the sodium level by 2.5 will give the corresponding level of salt (sodium chloride) (FSA 2003[2]).

It should also be noted that in some foods sodium chloride (salt) is not the only source of sodium, e.g. baked products will often contain baking powder (sodium bicarbonate).

The figures in Table 3 are all taken from those published on the FSA website. NaCl concentrations are calculated from Na levels, given by FSA in their October 2003 table using the multiplier of 2.5. E.g. to convert Na concentration into NaCl concentration. The current salt level in bacon is given by FSA as 1491 mg/100g Na; this is equivalent to 1.491% Na, which is converted to % salt (NaCl) by multiplying by 2.5, which gives 3.73% NaCl.

This report deals solely with meat products. It uses the current and proposed salt levels given by the FSA, and used a predictive microbiology system to model microbial growth under both conditions.

3. PREDICTIONS

Predictions were done using two predictive microbiology systems:-

(i) Growth Predictor – which supersedes Food Micromodel - uses data originally generated through MAFF projects and is available on the internet through the Institute of Food Research. Growth Predictor was used to model all pathogen growth (www.ifr.ac.uk).

(ii) Forecast – a modelling system developed by CCFRA for prediction of the growth of food spoilage microorganisms. Forecast was used to predict the growth of Enterobacteriaceae (www.campden.co.uk).

All predictions were based on a storage temperature of 8°C, the highest temperature that can be considered to be ‘chilled’ (Food Safety Temperature Control Regulations 1995).

4. MICROORGANISMS CONSIDERED

The following microorganisms or groups were considered within this investigation.

Salmonella:	A mesophilic food pathogen, second highest cause of reported infectious intestinal disease in the UK, and the organism responsible for the greatest number of outbreaks.
Listeria:	A psychrotrophic pathogen (*L. monocytogenes*) able to grow at chilled storage temperatures. *Listeria* tends to be more tolerant to salt than other bacteria.
Clostridium botulinum (psychrotrophic):	An anaerobic organism capable of producing a neurotoxin. Psychrotrophic strains are able to grow at chilled temperatures in modified atmosphere or vacuum packs.
Staphylococcus aureus:	A mesophilic organism capable of producing a range of toxins which cause vomiting. The toxins are highly heat resistant and once formed are unlikely to be inactivated by subsequent cooking. Staphylococci tend to be relatively salt tolerant.
Clostridium perfringens:	A mesophilic organism which can infect consumers, allowing a toxin to be formed ‘in vivo’ which results in food poisoning. This organism can be a problem if foods are not cooled quickly enough after cooking, as growth can occur, resulting in high levels of the organism in foods.
Enterobacteriaceae:	A family of indicator organisms, this family contains the ‘enteric’ organisms including pathogens/potential pathogens such as *Salmonella*, *E. coli* and *Yersinia enterocolitica*. The group also contains non-pathogens which may, if they grow to high levels, influence product quality and shelf life.

The pH conditions used for each of the foods was based on best estimates of product pHs derived from literature and the knowledge base at the Meat and Livestock Commission. The following pH values were used throughout:

Bacon	pH 5.5
Ham	pH 5.5
Sausages	pH 6.0
Burgers	pH 5.5
Meat Pie	pH 6.0

5. RESULTS OF PREDICTIONS

5.1 Bacon and Ham

The previous and proposed salt levels for bacon and ham are the same for both products. Microbiologically the products are very different, as bacon tends to be sold raw to consumers for cooking and 'hot' consumption, whilst ham tends to be sold to the consumer in a cooked ready-to-eat form.

5.1.1 *Salmonella*

Figures 1, 2 and 3 show the effects of changing salt concentration to those proposed for bacon and ham, on the growth of *Salmonella*. The predictions assume a pH of 5.5 and storage temperature of 8°C. Predictions have been done both including and excluding nitrite curing salt at 120ppm and 100ppm respectively for bacon and ham (legal levels).

The predictions indicate that in all cases the growth of *Salmonella* occurs and is promoted by the inclusion of less salt, with the lag phase being slightly shorter (i.e. growth starts more quickly) and a better growth rate being achieved.

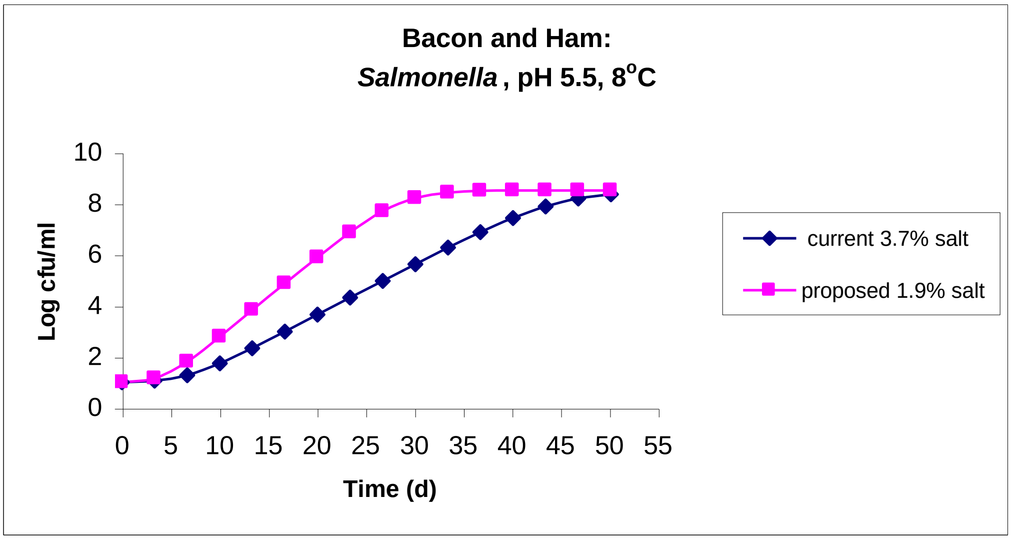

Figure 1

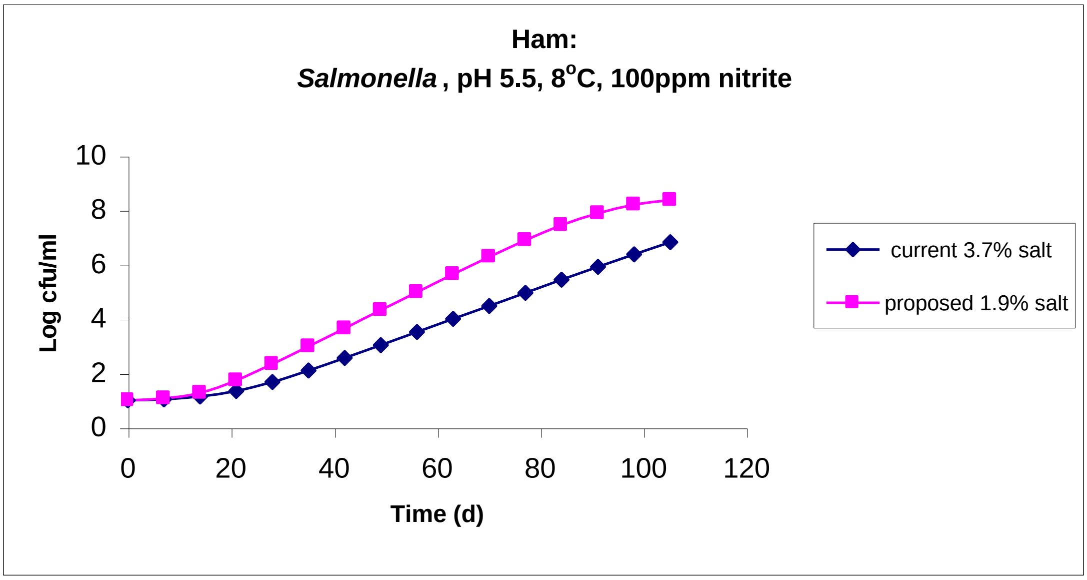

Figure 2

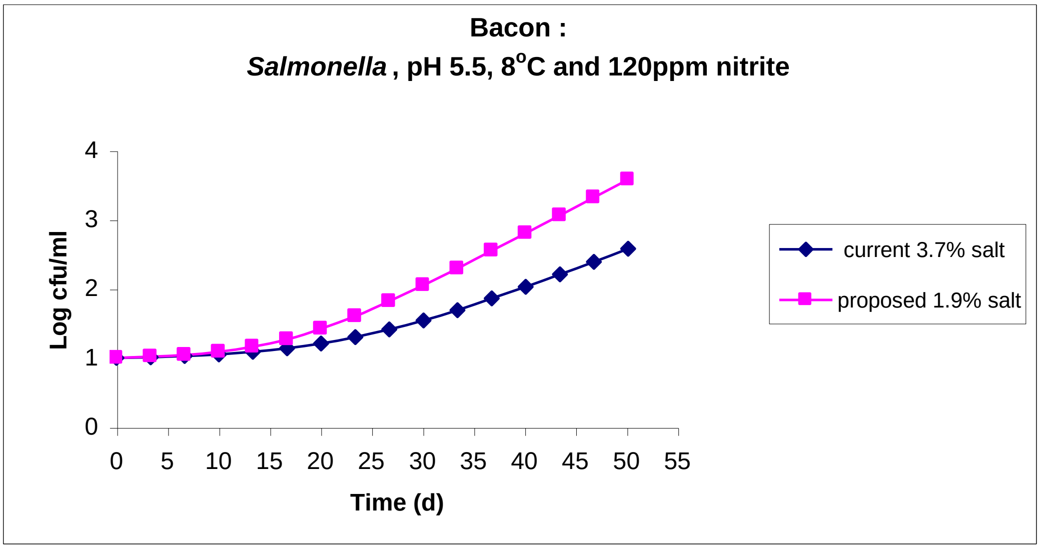

Figure 3

5.1.2 *Listeria*

Figures 4, 5 and 6 show the effect of changing salt levels to those proposed for bacon and ham, on the growth of *Listeria*. In all cases reducing salt levels slightly decreases the lag time, and increases the growth rate. This will lead to greater population developing in a given time in the product containing lower salt levels.

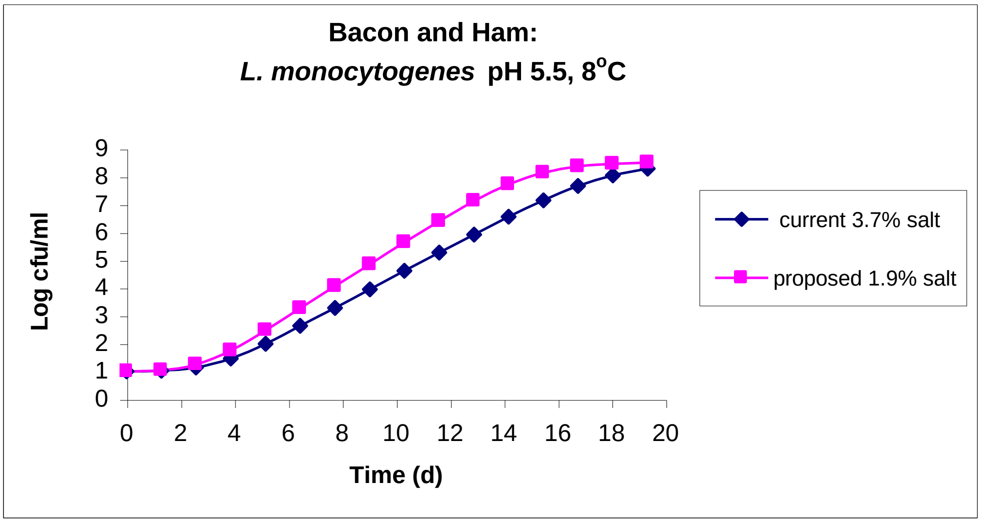

Figure 4

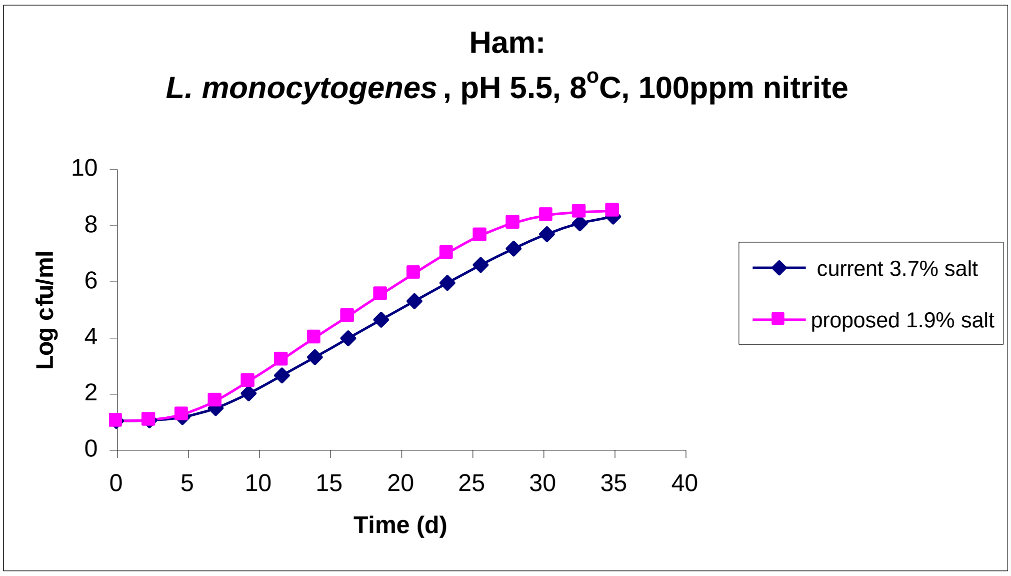

Figure 5

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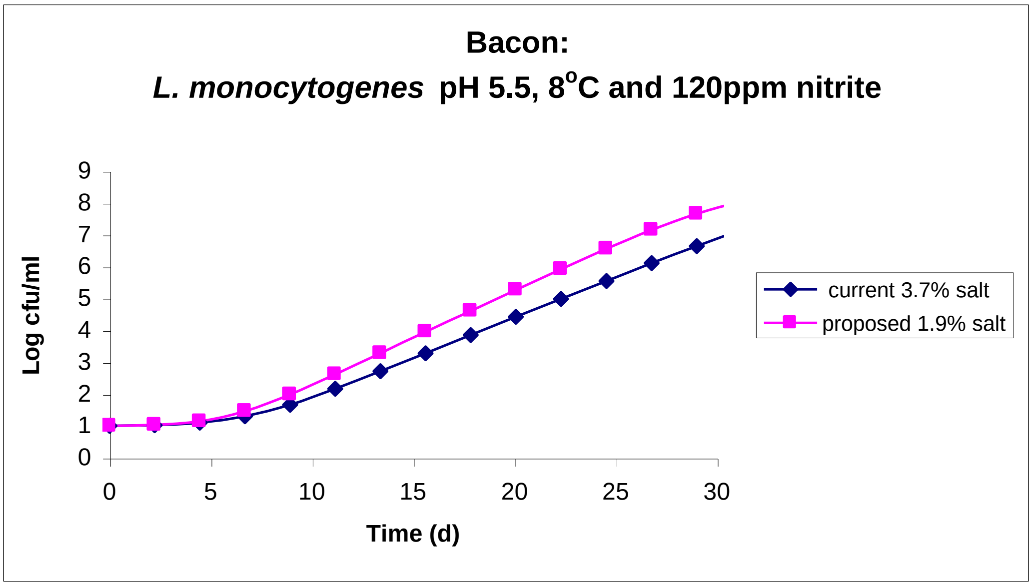

Figure 6

5.1.3 *E. coli* O157

Figure 7 shows the effect of changing salt levels to those proposed for bacon and ham, on the growth of *E. coli* O157. In this case the model does not allow for the effects of nitrite to be included. Results show that at reduced salt levels the lag time is shorter and the growth rate higher in the lower salt level foods.

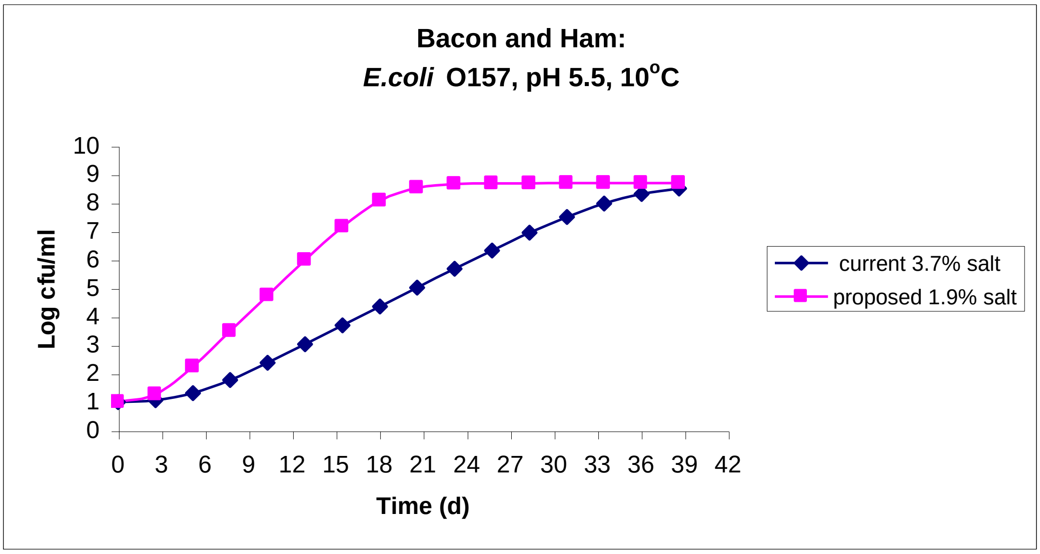

Figure 7

5.1.4 *Cl. botulinum* (psychrotrophic)

Figure 8 shows the effect of changing salt levels to those proposed for bacon and ham, on the growth of psychrotrophic *Cl. botulinum*. In this case the model does not allow for the effect of nitrite to be included. The results show a large difference in the response of the organism. In lower salt conditions the lag time is much shorter (approximately 9 days in lower salt conditions, compared to approximately 22 days in higher salt conditions) and the growth rate higher. This result is of great interest when considering guidance on the control of psychrotrophic *Cl. botulinum* in vacuum packed (VP) and modified atmosphere packed (MAP) products. One of the control factors noted by the Advisory Committee for the Microbiological Safety of Foods (ACMSF 1992), the MAP/VP industry code of practice (1996) and reiterated in Draft FSA guidance (2004) in these products, is the use of 3.5% salt (or greater). This acknowledges the importance salt can make in assuring the microbiological safety of these types of products.

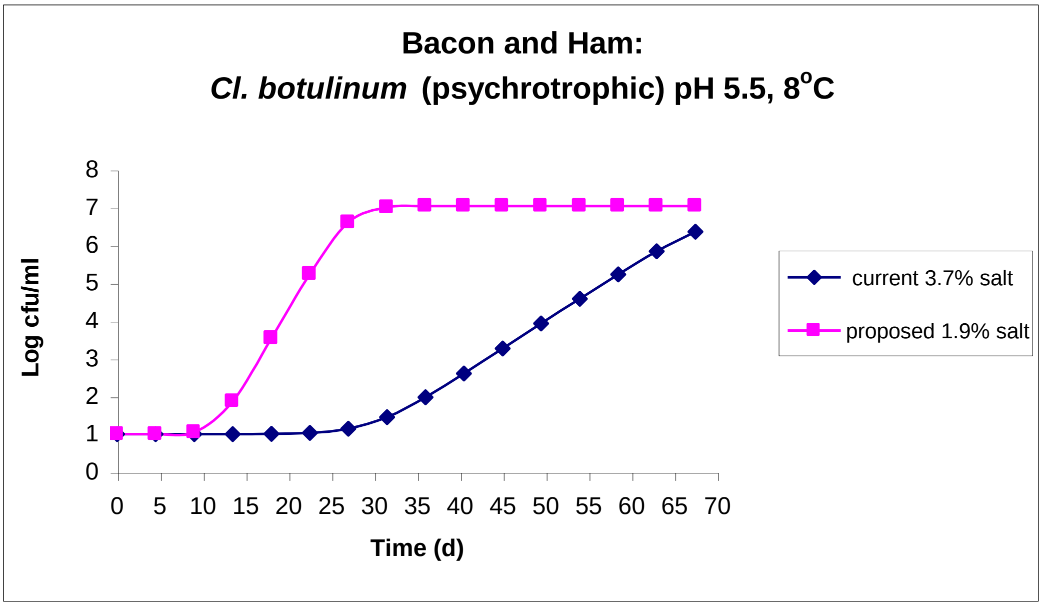

Figure 8

5.1.5 *Staphylococcus aureus*

Of all of the pathogenic foodborne bacteria, *S. aureus* is able to grow at the lowest water activity (and thus the highest salt concentration). It would therefore be expected that changing salt levels in foods such as bacon and ham would have less of an effect on this organism than others.

The results shown in Figure 9 do still show an increase in growth rate due to the lower salt level; however, it is not as great as that seen with other organisms. The lag time for *S. aureus* is similar at both salt levels.

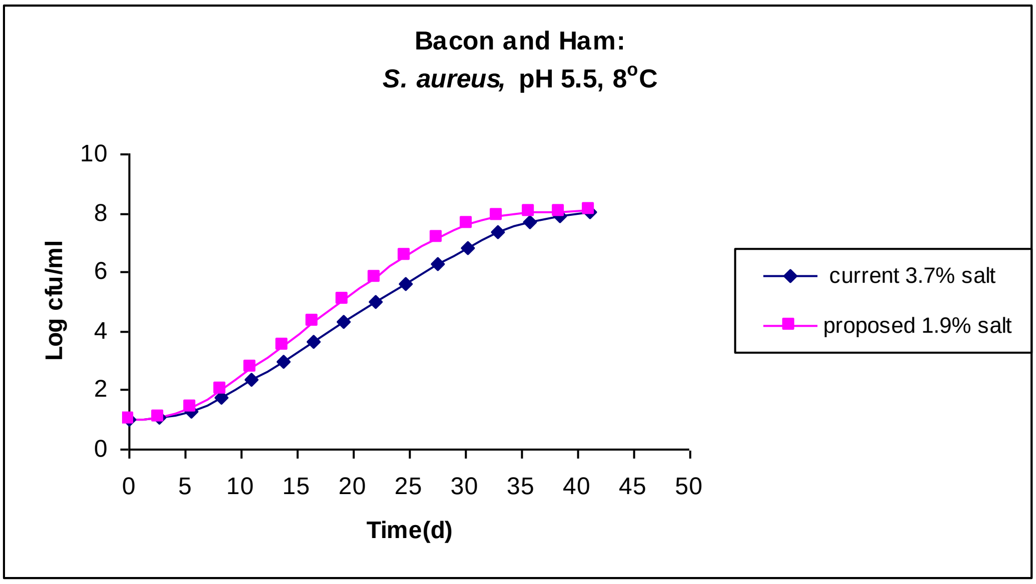

Figure 9

5.1.6 *Clostridium perfringens*

Cl. perfringens does not grow under chilled conditions; its minimum growth temperature has been reported as 12°C and the main concern is the survival of spores after a cooking process, which could then grow during cooling of the cooked food. This can be a particular concern when cooking large volumes of food or very large cuts of meat. The predictions for this organism have therefore been done at 22°C, to show the possible effects of different salt concentrations on the growth of this organism, during cooling. The results (Figure 10) indicate that reducing salt levels to those proposed for bacon and ham will decrease lag time and increase growth rate, increasing the microbiological risk associated with the growth to harmful levels of *Cl. perfringens* in these type of products during a cooling phase after cooking.

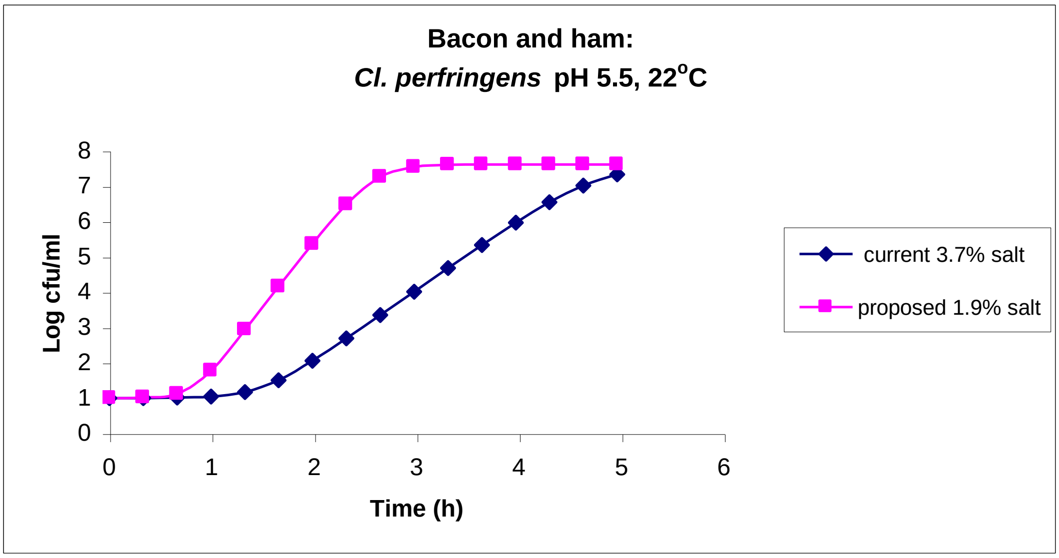

Figure 10

5.1.7 Enterobacteriaceae

Predictions of the growth of Enterobacteriaceae are shown in Figure 11. Results show that reducing the salt levels as proposed for bacon and ham, gives a large reduction in lag phase and an increase in growth rate.

If the predicted data are used together with the PHLS Guidelines for the Microbiological Quality of Some Ready-to-Eat Foods at the Point of Sale (PHLS 2000), then a ready-to-eat ham containing 10^2/g Enterobacteriaceae on day 0 of its life would become unsatisfactory (a count >10^4 Enterobacteriaceae) after approximately 75 hours (3.1 days) if the proposed reduced salt level were used, whilst at the current higher level this point would be reached at 200h (8.3 days).

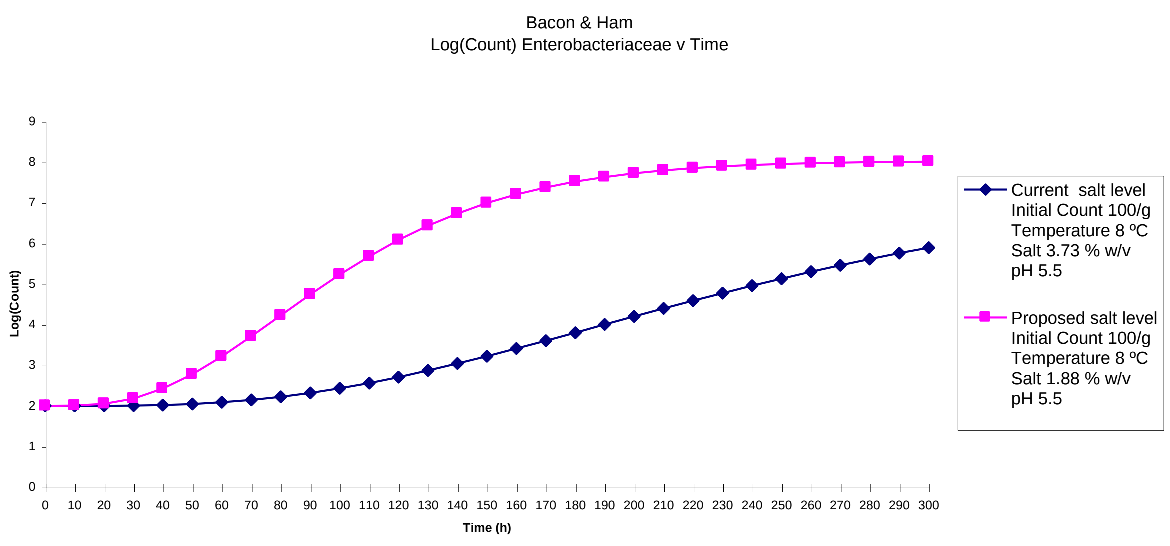

Figure 11

5.2 Sausages

The changes in salt levels proposed for sausages are not as great as those proposed for bacon and ham. It is acknowledged that some British sausages will contain metabisulphite; however, as no predictive models are available that include this factor, it could not be included in these predictions.

5.2.1 *Salmonella*

The effect on the growth of *Salmonella* of changing salt levels as proposed for sausages, is shown in Figure 12. The lag time at both salt levels is essentially the same; however, the growth rate is higher at the lower salt level.

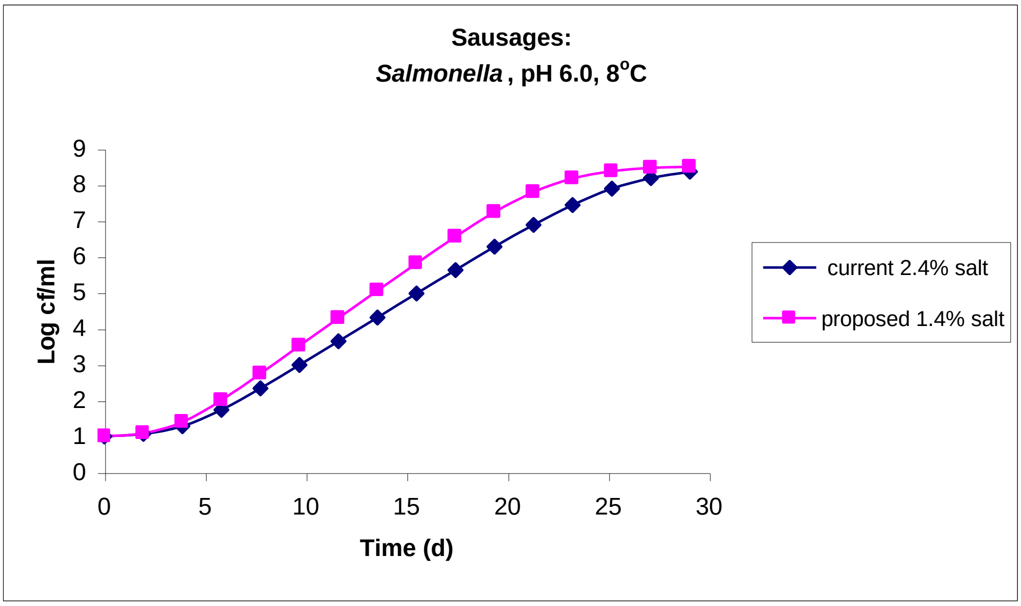

Figure 12

5.2.2 *Listeria*

The effect on *Listeria* growth of changing salt levels as proposed for sausages is shown in Figure 13. As noted previously, *Listeria* is more salt tolerant than many other bacteria; the results of the predictions show this, with a reduction from 2.4% to 1.4% causing no change to the lag time, and little change in growth rate.

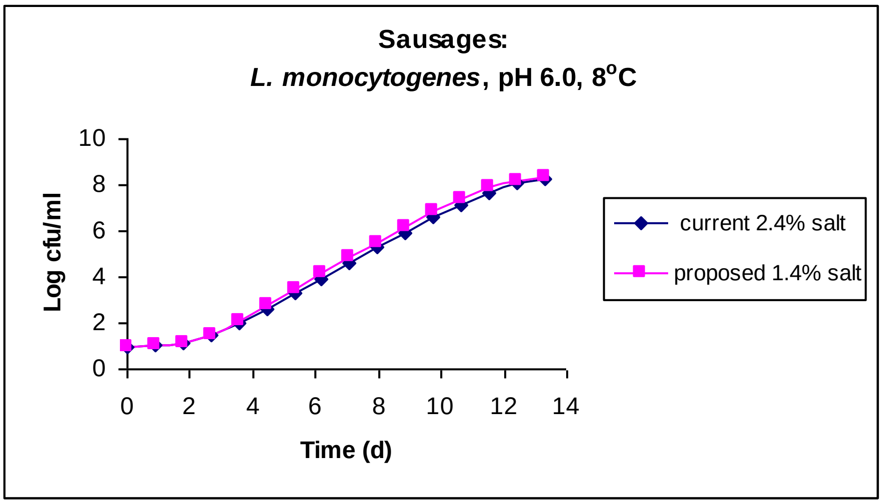

Figure 13

5.2.3 *E. coli* O157

The effect on the growth of *E. coli* of changing the salt levels as proposed for sausages is shown in Figure 14. The lag time for both salt levels is approximately the same; however, the growth rate for the proposed reduced salt level is higher than that for the current level.

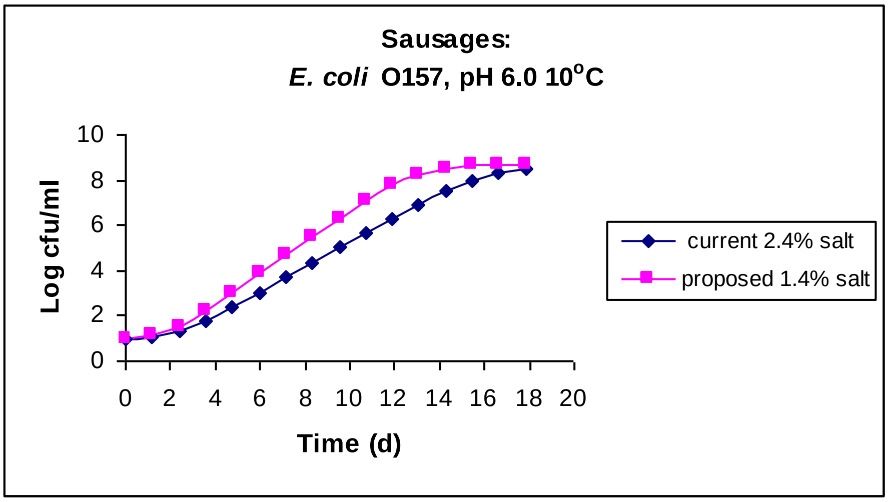

Figure 14

5.2.4 *Cl. botulinum* (psychrotrophic)

Figure 15 shows the effect of changing the salt levels as proposed for sausages on the growth of *Cl. botulinum*. In this case the proposed lower salt level results in a reduced lag time and faster growth rate. The risk of growth of *Cl. botulinum* under these conditions would be greater in the lower salt recipe.

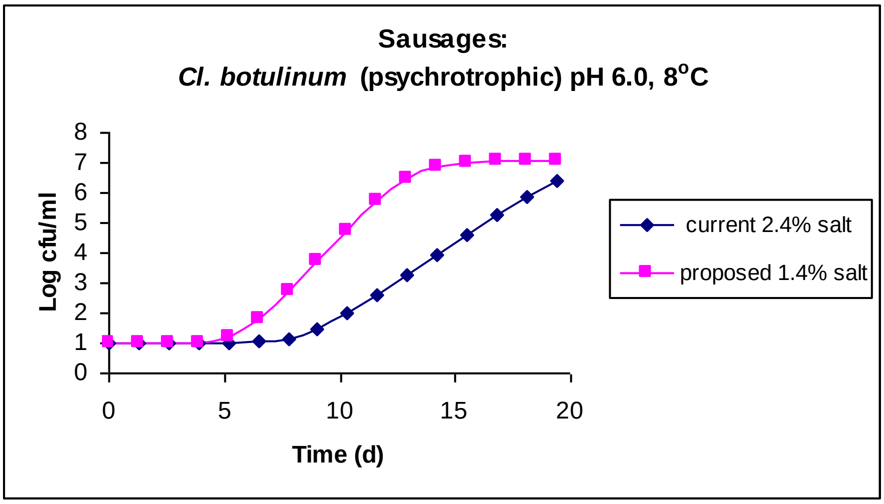

Figure 15

5.2.5 *S. aureus*

The effect of changing salt levels as proposed for sausages on the growth of *S. aureus* is shown in Figure 16. As noted previously, *S. aureus* shows greater tolerance to salt than many other food pathogens; the predictions show this effect well with the different salt levels causing little difference in either growth rate or lag time.

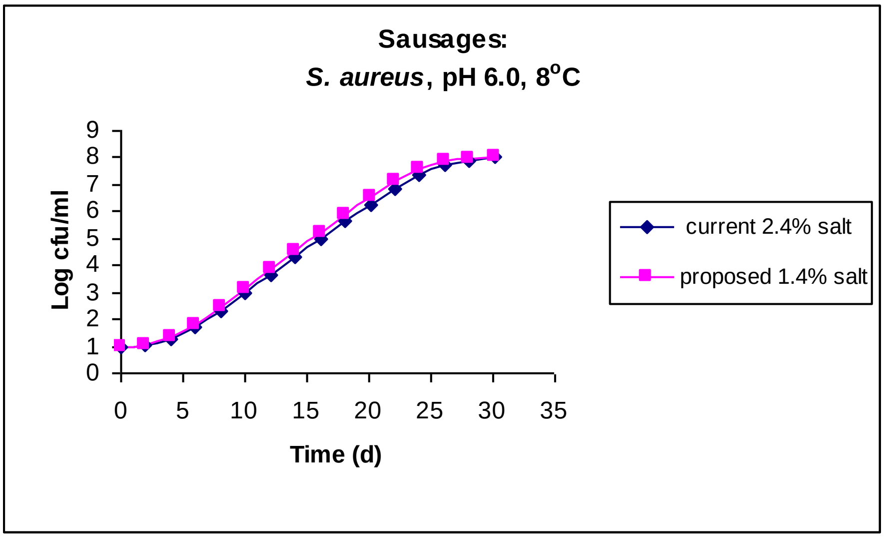

Figure 16

5.2.6 *Cl. perfringens*

As noted previously the predictions for *Cl. perfringens* have been done at a temperature of 22°C to give an indication of growth potential during the cooling phase of a process.

Results (Figure 17) show that reducing the salt levels as proposed for sausages will result in approximately the same lag time as the current higher salt level, but would also give a slightly faster growth rate.

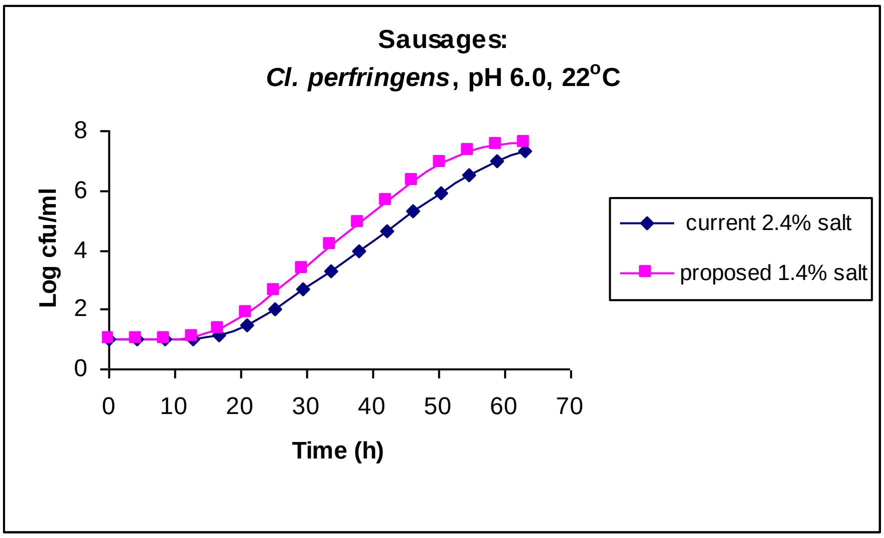

Figure 17

5.2.7 Enterobacteriaceae

The change in salt levels as proposed for sausages is predicted to reduce the lag time and increase the growth rate of the Enterobacteriaceae (Figure 18).

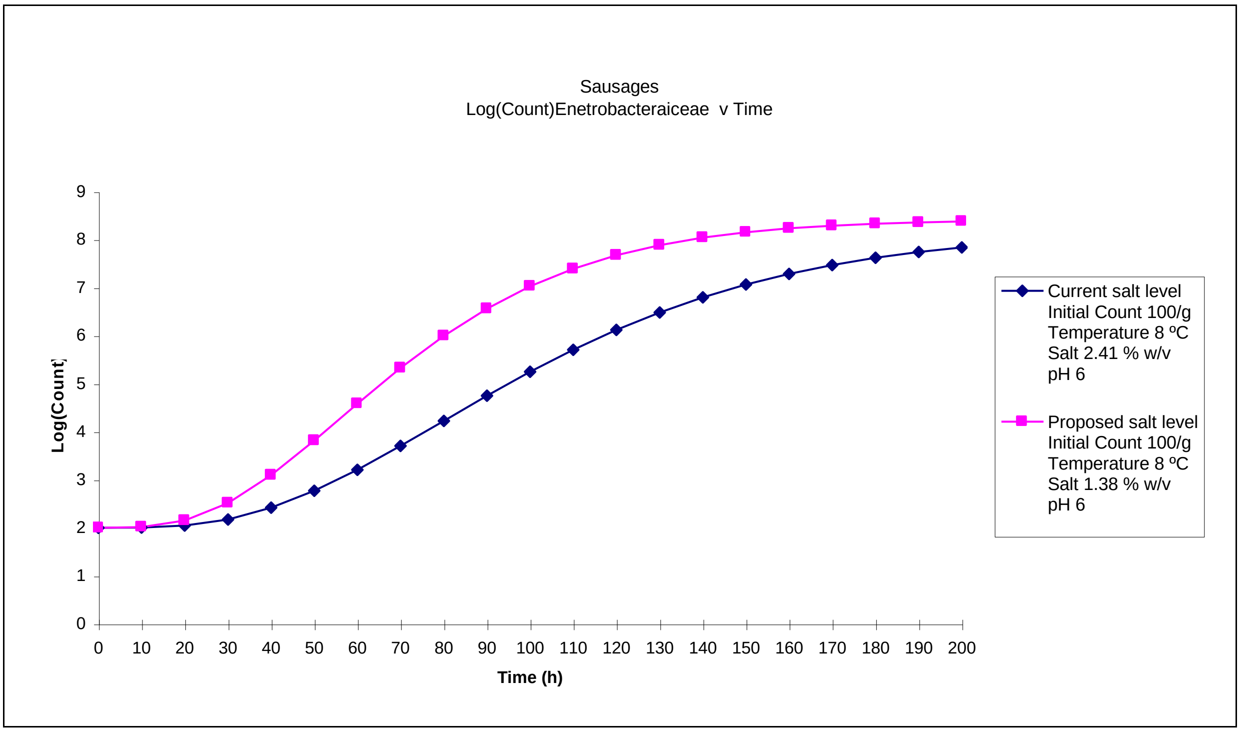

Figure 18

5.3 Burgers

The changes in salt level proposed for burgers is less than for ham/bacon or sausages, at 0.5%.

Depending on the recipe used to make the burger, they may contain metabisulphite. For the purpose of this study it is assumed that the burger is composed of 100% meat and therefore will not contain metabisulphite.

5.3.1 *Salmonella*

The effect of a change in salt levels as proposed in burgers on the growth of *Salmonella* is shown in Figure 19. The prediction suggests that the proposed change would have little effect on either the lag time or growth rate of *Salmonella* in these products.

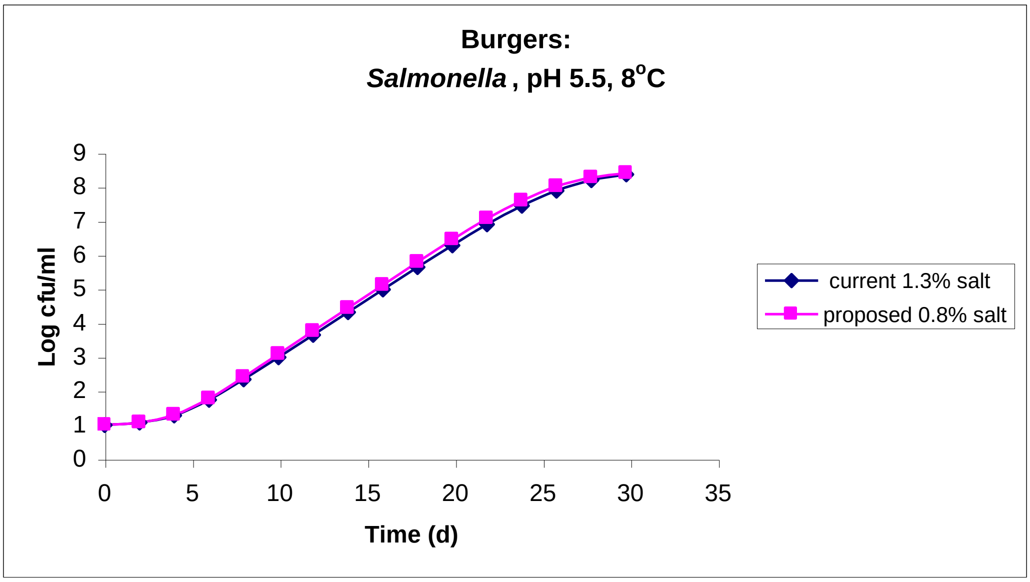

Figure 19

5.3.2 *Listeria*

The effects of the proposed change in salt levels in burgers on the growth of *Listeria* is shown in Figure 20. The change is predicted to have little effect on either the lag time or growth rate of this organism in these products.

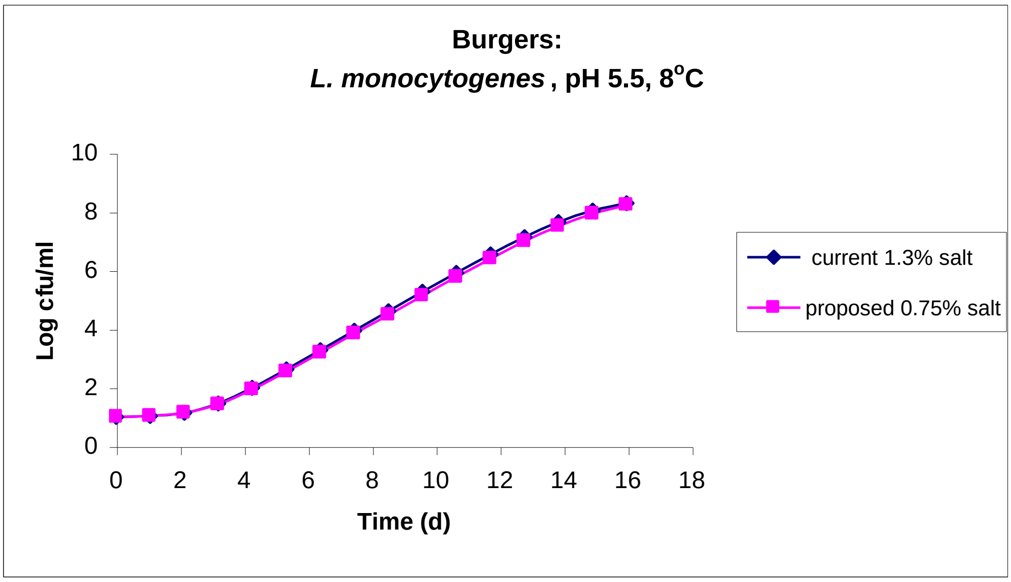

Figure 20

5.3.3 *E. coli* O157

The effects of the proposed salt reduction in burgers on the growth of *E. coli* O157 is shown in Figure 21. There would appear to be little change in the predicted lag time; the growth rate at reduced salt levels is, however, higher than that observed with the higher salt level.

Considering the previous association of outbreaks of *E. coli* O157 food poisoning with burgers, this result is worth considering. Many food processes are designed to achieve a 6 log reduction in vegetative food pathogens such as *E. coli* O157. If, by a change in salt level, the numbers of such organisms are allowed to increase, then a process designed for a higher salt level product may not be sufficient to ensure reduction of such organisms to a safe level. In the case of the predictions shown here, if *E. coli* O157 were present in a raw burger at a low level (10/g), then a level of 10^6/g is predicted to be reached approximately 1.5 days earlier at a lower salt level (approximately 9.5 days with lower salt, compared to approximately 11 days with higher salt). Thus, the microbiological risk is predicted to increase in lower salt burgers.

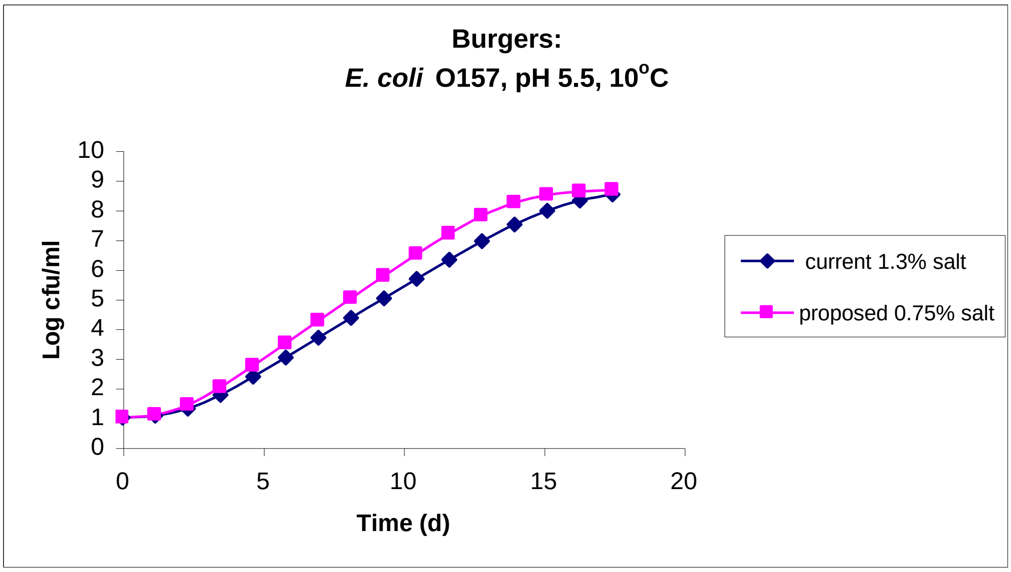

Figure 21

5.3.4 *Cl. botulinum* (psychrotrophic)

Figure 22 shows the effect of the proposed changes in salt levels as proposed for burgers, on the growth of psychrotrophic *Cl. botulinum*. The predictions indicate a slightly reduced lag time and an increased growth rate at the lower salt level. The effects are less pronounced than those predicted in bacon/ham or sausages, where differences between the higher and lower salt levels are greater.

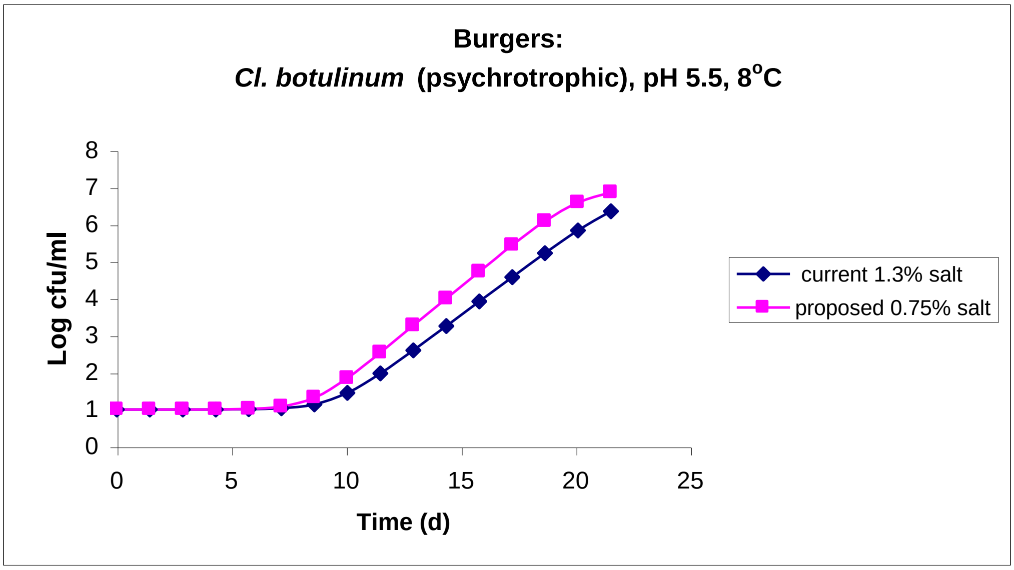

Figure 22

5.3.5 *S. aureus*

Figure 23 shows the effect of the proposed changes in salt levels for burgers on the growth of *S. aureus*. As noted previously, this organism is reasonably tolerant to salt and the predictions suggest that the changes would not affect the growth of this organism.

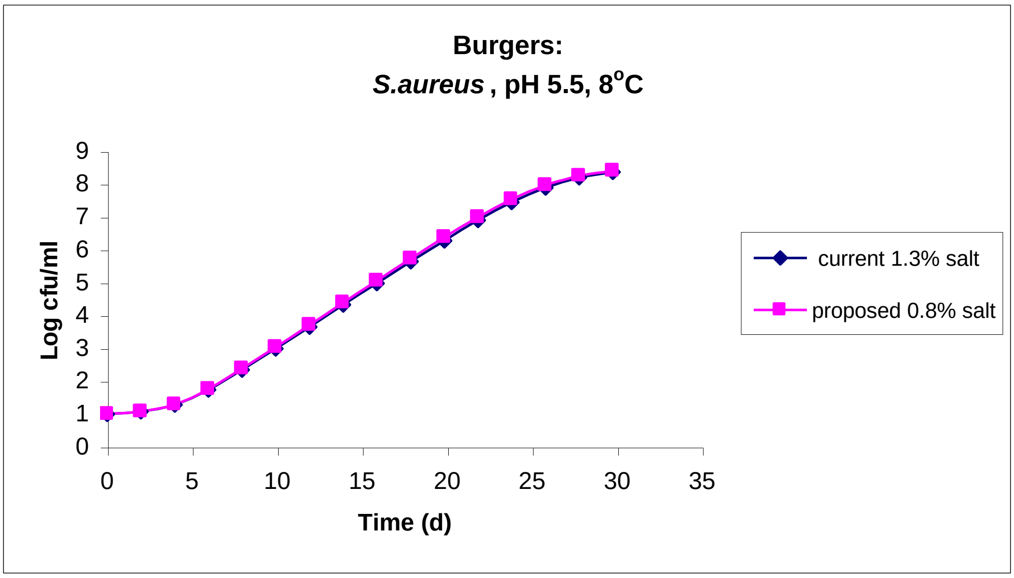

Figure 23

5.3.6 *Cl. perfringens*

The effect of the proposed changes in salt level in burgers on the predicted growth of *Cl. perfringens* at 22°C is shown in Figure 24. The predictions suggest that the change in salt level would have no effect on the lag time and very minor effects on the growth rate of this organism.

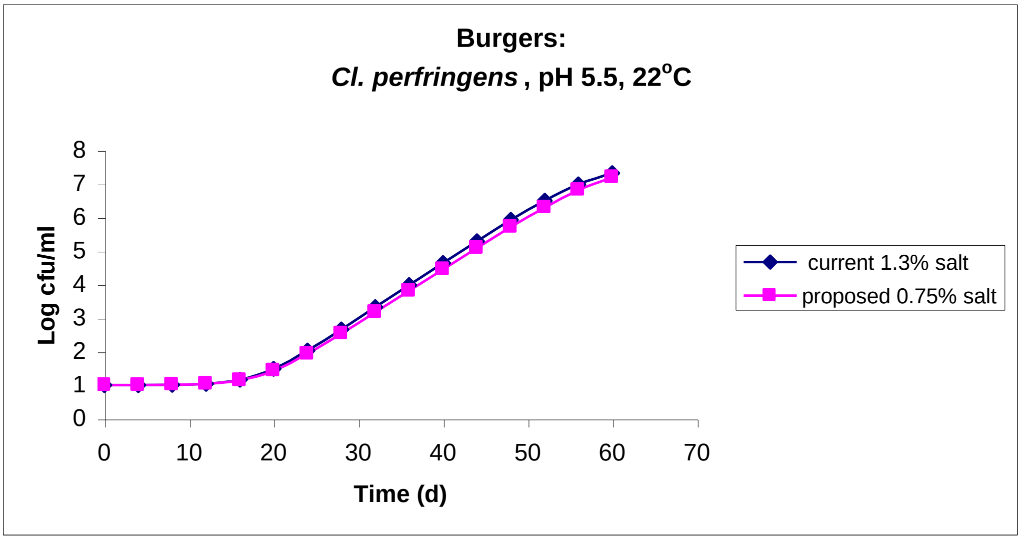

Figure 24

5.3.7 Enterobacteriaceae

The effect of the proposed changes in salt level in burgers on the predicted growth of Enterobacteriaceae is shown in Figure 25. The results suggest a minor reduction in lag time at the lower salt level, and an increase in growth rate.

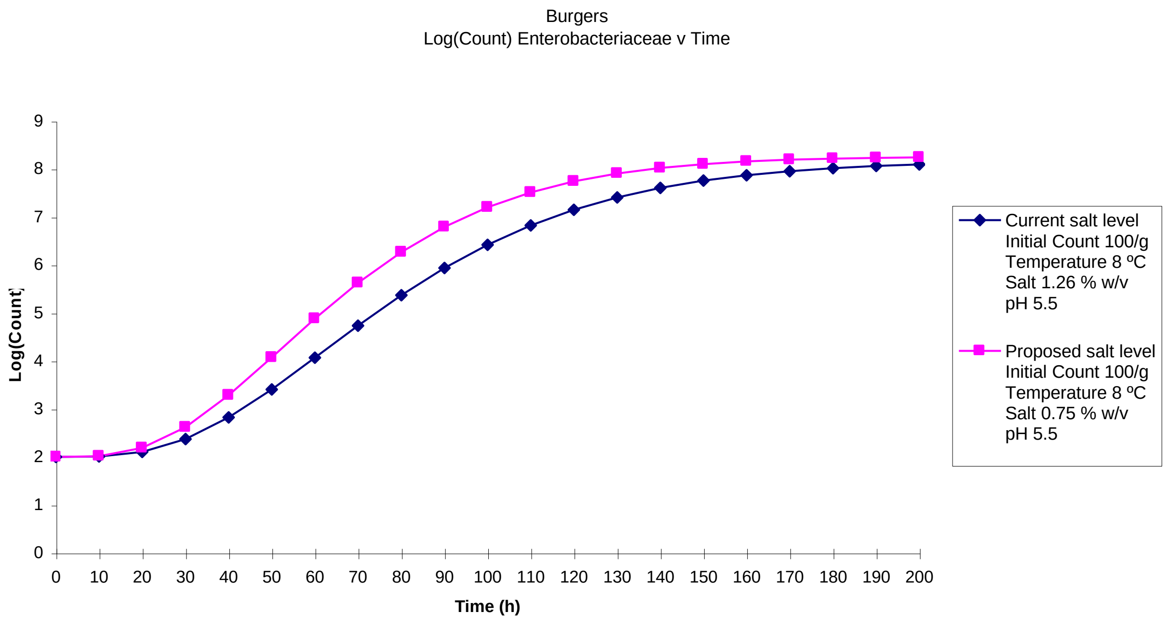

Figure 25

5.4 Meat Pies

5.4.1 *Salmonella*

The effects of the proposed changes in salt level in meat pies on the predicted growth of *Salmonella* is shown in Figure 26. The predictions suggest there would be no change in lag time or growth rate.

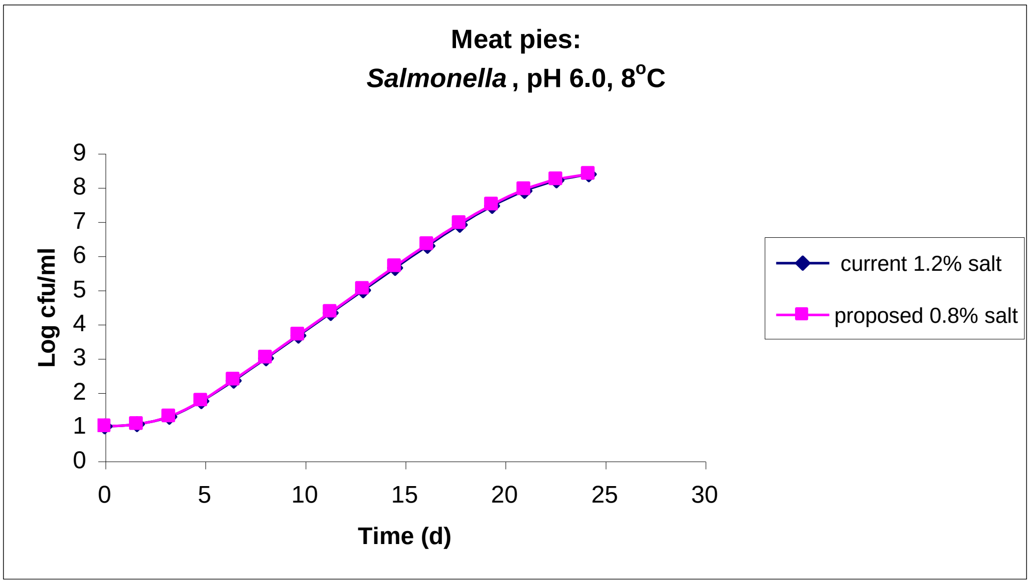

Figure 26

5.4.2 *Listeria*

Figure 27 shows the predicted changes in the growth of *Listeria* at current and proposed salt levels in meat pies. Predictions indicate there would be little change in either lag time or growth rate.

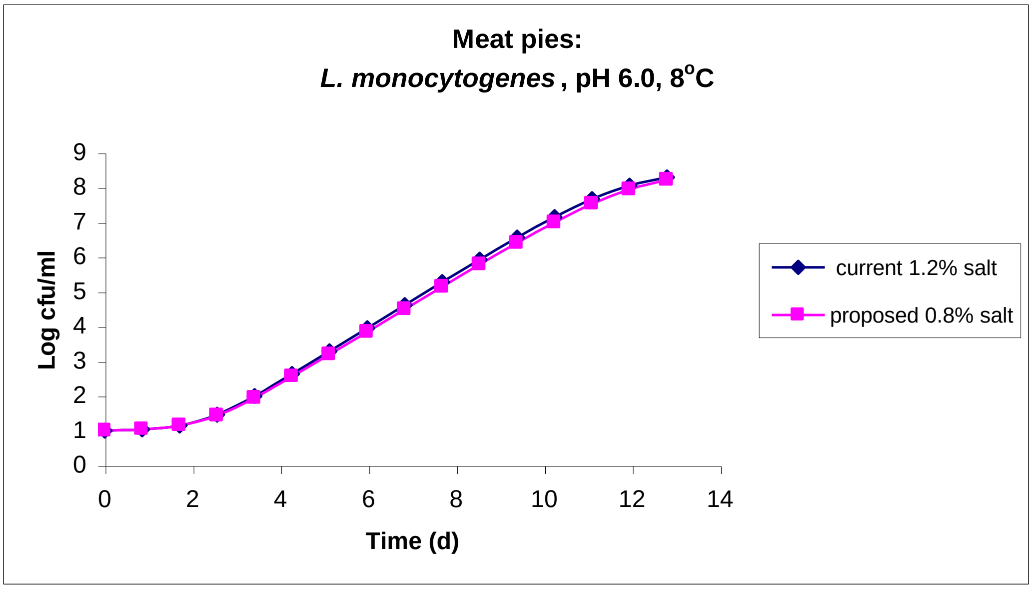

Figure 27

5.4.3 *E. coli* O157

The effect of a change in salt level as proposed for meat pies on the growth of *E. coli* O157 is shown in Figure 28. Results suggest no change in lag time, but a small increase in growth rate at the lower salt level.

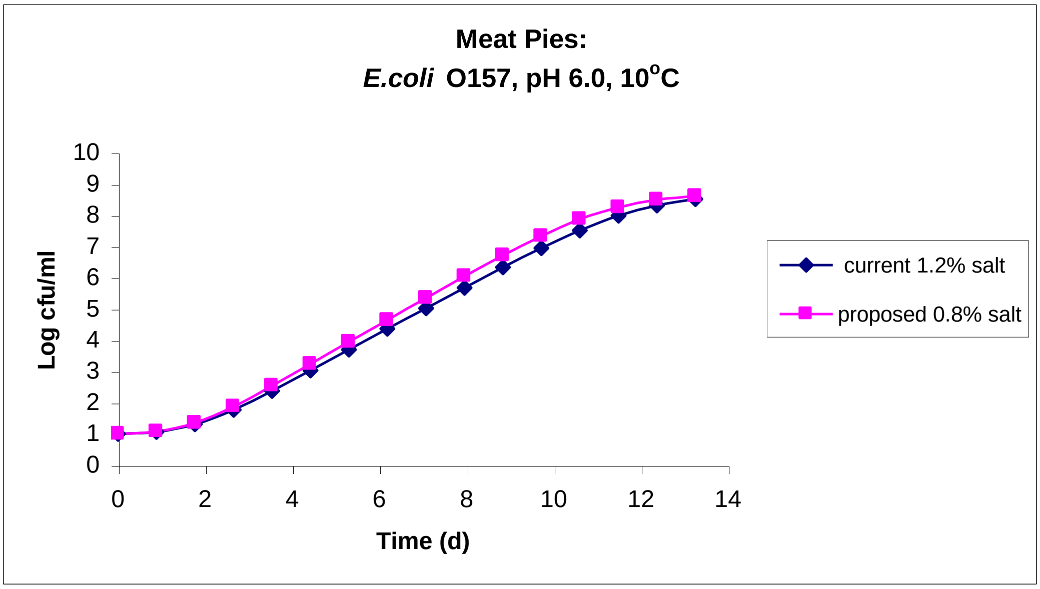

Figure 28

5.4.4 *Cl. botulinum* (psychrotrophic)

Figure 29 shows the effect of a change in salt level as proposed for meat pies, on the growth of psychrotrophic *Cl. botulinum*. The results show that the lower salt level results in a very slightly shorter lag time, and a slightly faster growth rate.

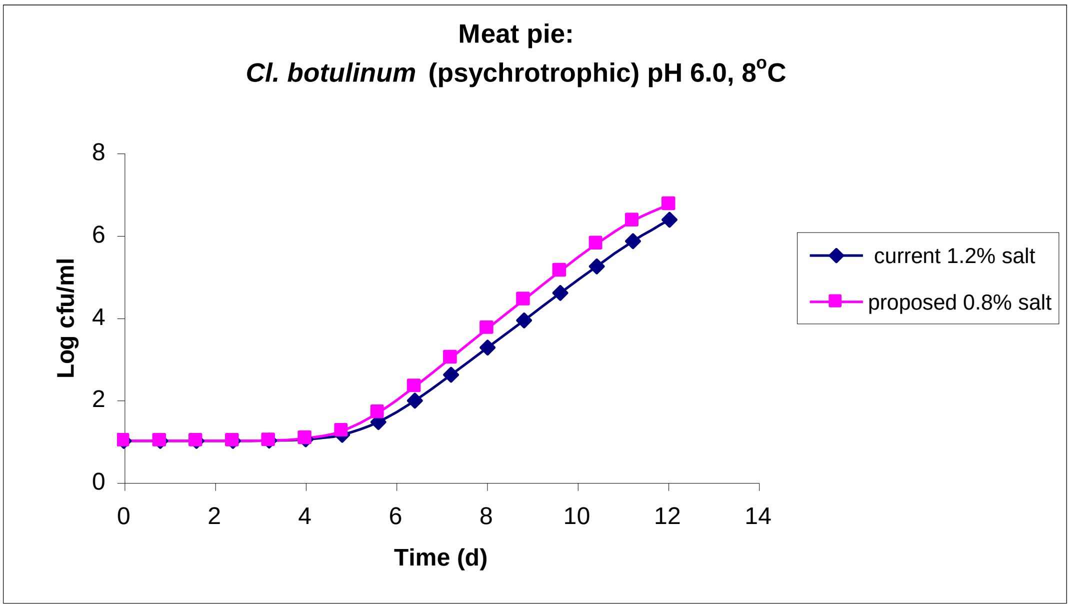

Figure 29

5.4.5 *S. aureus*

Figure 30 shows the effect of a change in salt level as proposed for meat pies, on the growth of *S. aureus*.

The lower salt level does not affect the predicted growth of this organism.

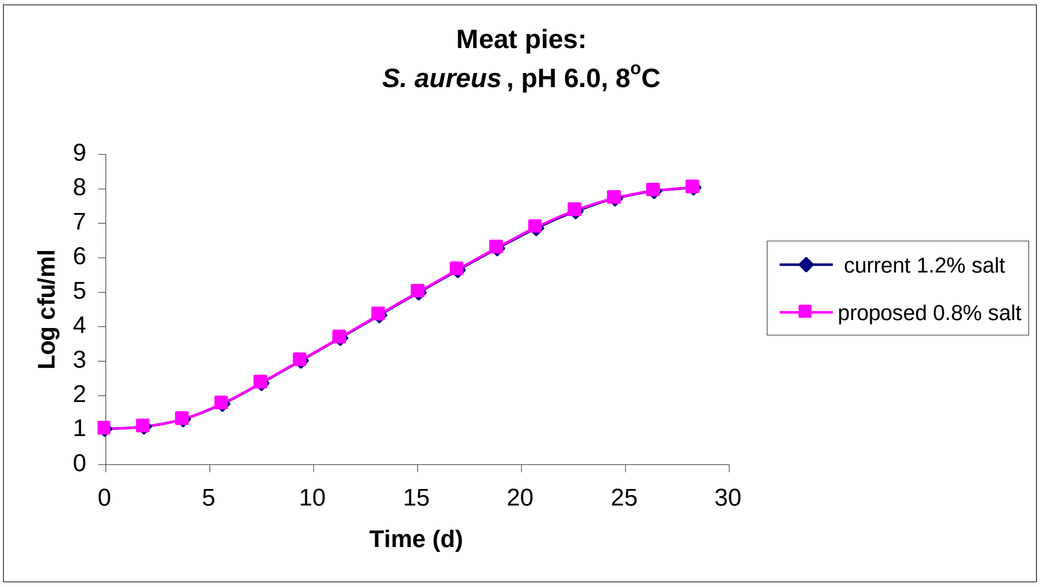

Figure 30

5.4.6 *Cl. perfringens*

The effect of the proposed changes in salt level in meat pies on the predicted growth of *Cl. perfringens* at 22°C is shown in Figure 31. The predictions suggest that the change in salt level would have no effect on the lag time, and minor effects on the growth rate of this organism.

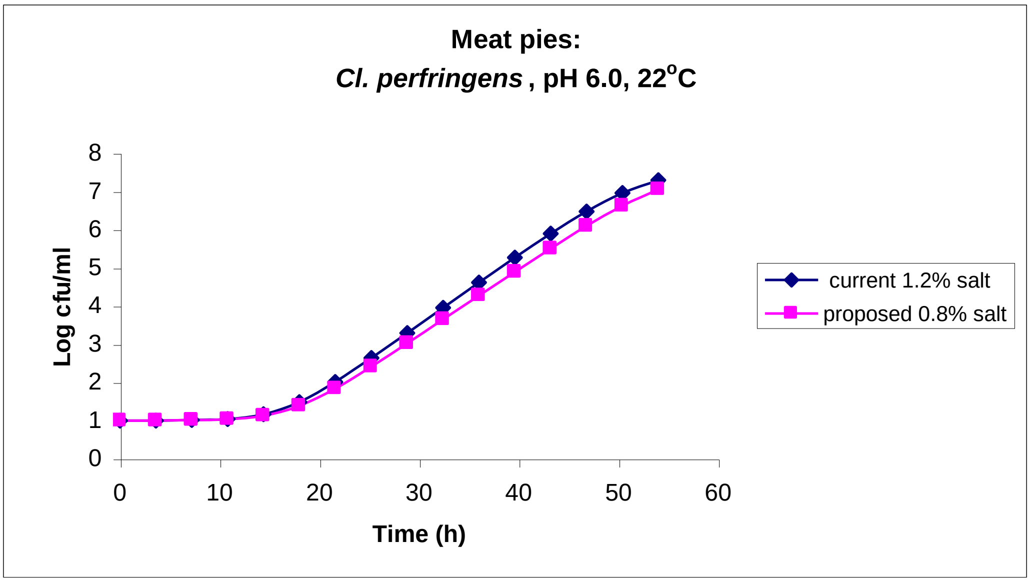

Figure 31

5.4.7 Enterobacteriaceae

The effect of the proposed changes in salt levels in meat pies on the predicted growth of Enterobacteriaceae is shown in Figure 32.

The results suggest that the lower salt level does not affect the lag time, but does result in a slightly faster growth rate.

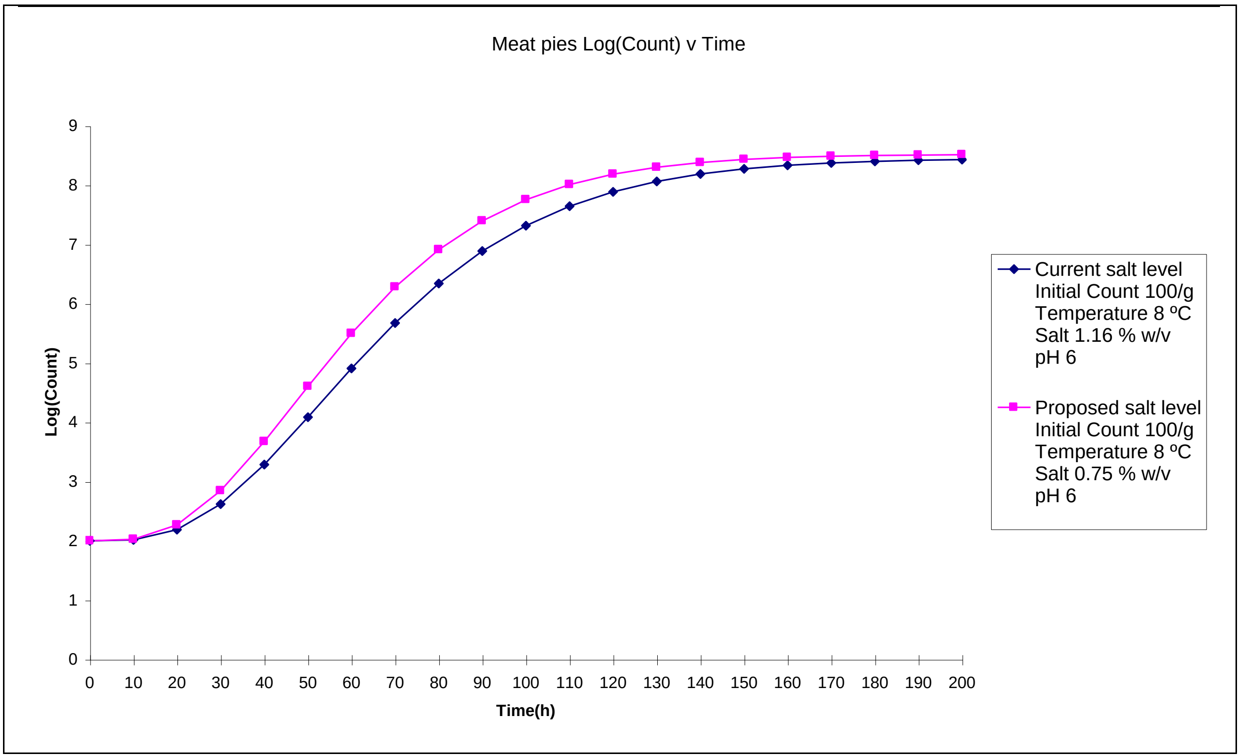

Figure 32

6. CONCLUSIONS

In the introduction of this report, it was noted that salt is included in food products for a number of reasons:- organoleptic, structural, microbiological. This report solely considers the microbiological implications of reductions in the salt levels in meat products.

The predictions produced in this report clearly show that the effects of a reduction in salt are varied, depending on the scale of the proposed reduction, and the microorganism being considered. Greater levels of reduction will have a greater positive effect on microbial growth. Considering the microorganisms themselves, a change in salt level has a much smaller (in some cases negligible) effect on salt tolerant organisms such as *S. aureus* or *L. monocytogenes*, than that observed in less salt tolerant types such as *Salmonella*, *E. coli* O157 or psychrotrophic *Cl. botulinum*. It is clear from the predictions given here, that a reduction in the level of salt in meat products could have implications to the microbiological risks inherent in such products. Risk could be increased in a number of ways:

(1) Reducing salt will create an environment in which certain microorganisms (including pathogens) are better able to grow to higher levels and therefore higher levels will result in higher risk.

(2) Higher levels of pathogens may result in the failure of a specified heat process to eliminate those pathogens from a product, resulting in higher risk.

(3) A lower salt level will result in a less inhibitory environment to organisms such as *Cl. perfringens* which could result in growth to higher levels during post cook cooling of bulk products. This would also result in increased risk.

Salt is used to control microbial growth. Results from predictions presented here indicate that, in some cases, changes from current salt levels to proposed levels will result in products less able to resist microbial growth, and therefore at greater risk from microbial spoilage and with a greater risk of allowing the growth of pathogens to higher levels. If any change in salt concentration in a product recipe is made, it will be absolutely essential that the producer fully understands the implications to product safety and the HACCP plan. A major concern is that whilst larger food producers will have the technical resource and ability to understand the implications of lowering salt concentrations on microbiological risk, smaller producers will not. This could result in salt levels being lowered without suitable risk consideration and HACCP reassessment being done.

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