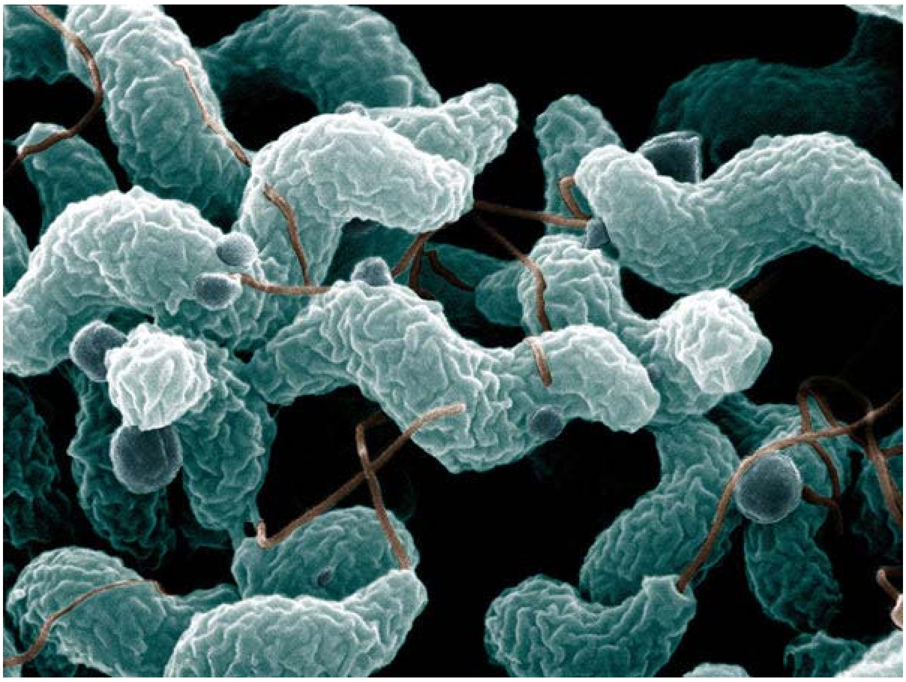

# Analysis of the costs and benefits of setting certain control measures for reduction of *Campylobacter* in broiler meat at different stages of the food chain

**Final Report**

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# Analysis of the costs and benefits of setting certain control measures for reduction of *Campylobacter* in broiler meat at different stages of the food chain

## Final Report

A report submitted by ICF GHK
in association with ADAS

Date: 14 August 2012

Job Number: 30258939

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## Document Control

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# Contents

# 1 INTRODUCTION

## 1.1 This document and its purpose

This is the final report of a project undertaken by ICF GHK and ADAS for DG SANCO of the European Commission.

The purpose of the assignment is to provide the Commission with an analysis of the costs and benefits of applying certain control measures for reduction of *Campylobacter* in broiler meat to different stages of the broiler production and supply food chain.

The analysis has been commissioned to provide evidence that will inform the Commission's consideration and development of proposals for EU initiatives that will aim to reduce *Campylobacter* and the disease burden it imposes on the human population.

The control measures in the analysis considered were specified by the Commission. The list is based on the schedule of control measures considered in a Scientific Opinion issued by the European Food Safety Authority[1].

The content of this document are the responsibility of ICF GHK and ADAS. The project team has greatly benefitted from the advice of:

- Dr Maarten Nauta of the National Food Institute in the Technical University of Denmark;
- Professor Mieke Uyttendaele, Research Professor at Ghent University; and
- Professor Diane Newell, of Foodborne Zoonoses Consultancy and recently retired from the Veterinary Laboratories Agency, GB.

All these advisers were involved in the EFSA Working Group on Campylobacteriosis which produced the EFSA Opinions 2010 and 2011.

## 1.2 The context

### 1.2.1 Campylobacteriosis is the most commonly reported gastrointestinal illness in the EU

Campylobacteriosis, an infection by the *Campylobacter* bacterium, is associated with an inflammatory, sometimes bloody, diarrhoea or dysentery syndrome, mostly including cramps, fever and pain. It is often a foodborne illness.

*Campylobacter* is the most commonly reported gastrointestinal bacterial pathogen recovered from humans in the EU. While good progress has been made in recent years in reducing other causes of foodborne illness, such as *Salmonella*, *Campylobacter* has remained a persistent problem.

A total of 198,252 cases of campylobacteriosis were reported in the EU in 2009. The actual number of cases is thought to be very much higher. EFSA (2011) estimated the annual burden of disease at around 9 million cases per year and 0.35 million disability adjusted life years (DALYs).

### 1.2.2 Evidence suggests that much of the campylobacteriosis disease burden is associated with the presence of *Campylobacter* in poultry production and the supply chain

The principal reservoirs of *Campylobacter* are animals that are farmed for their meat e.g. chicken, pigs and cattle. Case-control epidemiological studies suggest that *Campylobacter* reaching consumers via the handling and consumption of broiler meat may account for 30% of cases of campylobacteriosis. However, recent source attribution studies using molecular epidemiological techniques indicate that additional cases are attributable to the chicken reservoir, though the routes of transmission are as yet unknown (EFSA 2010).

[1] Scientific Opinion on Campylobacter in broiler meat production: control options and performance objectives and/or targets at different stages of the food chain. EFSA, 2011.

*Campylobacter* is known to be widespread in the EU broiler production sector but prevalence rates vary very considerably across Member States. An EU-wide baseline survey was carried out at slaughterhouse level to determine the prevalence of *Campylobacter* in broiler batches and carcasses thereof in accordance with Decision 2007/516/EC[2]. The results were published by the European Food Safety Authority (EFSA) by the end of October 2009. At EU level the prevalence of *Campylobacter*-colonised broiler batches was 71.2% and that of *Campylobacter*-contaminated broiler carcasses was 75.8%. Member State prevalence varied from 2.0% to 100.0% and from 4.9% to 100.0%, for caecal contents and carcasses, respectively[3].

### 1.2.3 The industry has been taking steps to tackle the *Campylobacter* problem

Consumers can protect themselves from campylobacteriosis through careful storage and preparation and proper cooking of poultry meat, In particular the prevention of cross contamination of other foods in the kitchen is very important. Efforts to reduce the prevalence of *Campylobacter* in the broiler production sector, and its transmission through the supply chain, therefore complement food hygiene education and awareness-raising actions.

Tackling *Campylobacter* is a recognised priority for the poultry sector and the supply chain. The industry has been working with researchers and regulators to improve understanding of infection, transmission and control. Individual firms have conducted demonstration projects at different stages of the supply chain. Nevertheless, *Campylobacter* contamination remains widespread in many countries' broiler production systems.

Though broiler production is more consolidated and integrated than some other areas of food production, there are differences among countries in how the sector is organised and in prevailing operating practices. These, together with variation in climate and other influencing factors, caution against a 'one size fits all approach', but there is clearly more to do to reduce *Campylobacter* contamination of broiler meat at source.

### 1.2.4 This assignment will inform the European Commission's thinking as it develops proposals for an EU-wide strategic response to campylobacteriosis

In accordance with Regulation (EC) No 2160/2003 on the control of *Salmonella* and other specified food-borne zoonotic agents[4], EU targets can be established for the reduction of the prevalence of *Campylobacter,* as they have already been for the control of *Salmonella* in poultry populations.

Preparatory work to inform the setting of EU targets and associated control strategies has been undertaken. This work includes research and analysis by EFSA on the prevalence of *Campylobacter* in the broiler supply chain (as alluded to above) and on the identification and efficacy of alternative control measures.

The Commission requested EFSA to draft an opinion on *Campylobacter* in broiler meat production: control options and performance objectives and/or targets at different stages of the food chain. This opinion was adopted by the Scientific Panel on Biological Hazards of EFSA in March 2010[5] and presented for discussion to the Member States on the standing committee of the food chain on the 14th of April 2011.

That paper provides the starting point for this study, which considers the socio-economic impacts of some of the set of control measures that were examined by EFSA. It assesses the scale of likely costs associated with their implementation and the expected benefits, primarily in terms of the expected reduction in disease burden. It also considers aspects of their feasibility. The scope of the work is discussed in more detail in Section 2.

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[2] OJ L 190, 21.7.2007, p. 25.

[3] *The EFSA Journal* 2010, 8(03):1503

[4] OJ L 325, 12.12.2003, p. 1.

[5] *The EFSA Journal* 2011;9(4):2105

## 1.3 The report's structure

This document is structured as follows:

- Section 2 discusses the scope of the appraisal;
- Section 3 provides an overview of the EU broiler sector (complemented by more detailed reporting in Annex 3);
- Section 4 discusses the benefits of *Campylobacter* control;
- Section 5 explains the control measures that have been modelled;
- Section 6 provides the results of the strategic appraisal;
- Section 7 covers the issue of monitoring costs;
- Section 8 looks at how control measures can be best combined in cost-effective control measures;
- Section 9 discusses the potential economic and social impacts of the strategies;
- Section 10 provides some concluding comments.

Annexes provide supporting information on the project brief, references, details of the intervention measures, data on the efficacy of control measures, a description of the model and a summary of the project method. The cost project itself is also provided, under separate cover.

# 2 Scope and approach

## 2.1 The scope of the appraisal

This assignment has focused on the socio-economic implications of those control options that were examined by the EFSA Opinion (EFSA 2011). This report contains no new science and the scope is restricted to selected control options. It uses an assessment of costs and benefits of a range of control options to examine the relative impacts of potential components of a future control strategy.

The analysis was required to consider:

- cost of monitoring by food business operators;
- cost of monitoring by competent authorities to verify correct implementation by food business operators;
- cost of different control options and combinations of control options needed to obtain the objectives;
- cost of withdrawal or recall of products taking into account realistic scenarios;
- expected social impact;
- impact on imports of broiler meat;
- reduction of human health burdens.

The outputs are best viewed as a strategic appraisal. The report provides a high level indication of the relative impacts of alternative measures to inform the next phase in the development of the strategy and the dialogue among stakeholders. The assignment has also developed and provided a modelling tool that has been constructed so as to be amenable to further development and populated with new and additional data as they become available.

The work presented here provides a reference point for further, more detailed, studies of the impacts of the interventions that could be commissioned when the strategy is further advanced and more data are available. Limits to the 'resolution' of the current analysis are imposed by gaps in the economic, operational and scientific information. Some of the measures assessed here have yet to reach the market, others are not in use in the EU but are applied in other jurisdictions, others have been tested in demonstration projects within the EU industry but are not available (or have not been applied) at commercial scale.

### 2.1.1 Geographical scope

The analysis was required to consider the EU's 27 Member States and, as a starting point, the entirety of the EU's broiler supply chain. This immediately creates a point of differentiation from most previous studies, which have focused on efficacy and impacts on a single Member State or small number of Member States.

### 2.1.2 Production base

The study and associated modelling is restricted in scope to:

- Farmed flocks of broiler chicken (*Gallus gallus*);
- Indoor flocks only.

Flocks where birds are reared outdoors are excluded from the analysis as the on-farm measures considered are not applicable to such operations. These are a comparatively small share of overall production except in France. Some controls may not suit some small scale indoor flock owners that have their own processing facilities. These may be prevalent in certain Member States.

### 2.1.3 Temporal scope

It was agreed with the European Commission that the analysis would be applied for the period to 2020 (specifically 2014 to 2019). The agreed portfolio of control measures includes some that are not currently available in the commercial market, e.g. a vaccine, on the basis that they could become available if conditions were favourable to their development and deployment.

## 2.2 Approach

The project has involved:

- an appraisal of the available and relevant research evidence;
- definition of the measures to be assessed, building on the work published by EFSA (2011);
- gathering information on cost factors and operational metrics relevant to the specification of the impacts generated by application of those measures in the EU.

The two principal practical issues raised by the scope of this study are:

- The need to reflect the variation in production and supply chain structure across the EU, notwithstanding the fact that broiler production is more concentrated and integrated than many meat production systems;
- The research evidence base in this area is expanding year-by-year, as is the volume of experience gathered by the industry through demonstration projects and other initiatives. Nonetheless, the body of scientific evidence on the efficacy of individual interventions is, in many instances, restricted to experiments conducted in a relatively small number of Member States and the results cannot necessarily be extrapolated across the EU.

Additional sources of complexity and uncertainty include:

- The requirement for multiple possible interventions at various levels of the supply chain;
- The potential for interactions (positive, negative) among options;
- Variation in costs across the EU (especially labour costs);
- Potential for some variation in supply chain structure within the EU;
- Variation within the EU in the extent to which interventions will result in additional costs (based on baseline conditions and practice, and past investment).

The research programme for the study has attempted to address these challenges by collecting information on characteristics and costs for the broiler sector from across the EU. The assistance of the industry, including the Association of Poultry Processors and Poultry Trade (AVEC) and representative bodies for the poultry sector in a number of Member States has been helpful in this regard. Expert advisors have provided inputs on issues such as the transfer of efficacy results from country to country and the caveats associated with that process.

Some of the measures, if adopted, would result in very significant changes to the broiler production sector and the composition of the supply that it provides to the supply chain, retailers and consumers. These changes are non-marginal in nature and not readily simulated. Particular arrangements have had to be made in the analysis to accommodate these types of measures.

## 2.3 Approach to the model

A core task of this project was to produce a tool capable of assessing the costs and effects of implementing control measures for *Campylobacter* across the EU Member States. The tool also had to able to determine the least cost combination of measures that will achieve a requested reduction in *Campylobacter* incidence.

The response to this task was to develop a reusable spreadsheet based modelling tool which allows a user to explore the costs of implementing control measures and the effects of these measures, both in terms of a reduction in the incidence of *Campylobacter* in poultry meat and also a change in the number of DALYs.

The model is driven by a large quantity of data, representing industry data, specific cost elements of control measures and potential and maximum uptakes of these measures. The default values in the model have been generated from the evidence gathering phases of this project but all these values can be edited by the users of the model, if for example improved data becomes available in time. All the data values can also be varied by Member State, in order to reflect the differences in the poultry industry across the EU.

The model takes the form of an MS Excel workbook with a user friendly interface, consisting of controls directly on the worksheets. Appropriate sections of the workbook are protected to prevent accidental modification to formulae by end users, but the password is provided so that full access is possible if desired. Each part of the model also has a link to the appropriate section of an internal help page, which documents the functionality in order to ensure ease of use.

There are 2 main functions of the model:

(i) Firstly a user can **assess the cost and effect of a chosen set of control methods** applied to a chosen area. The user is able to select an area (single Member State, multiple Member States, EU-wide) and the control methods they wish to apply across this area. The tool can then display a breakdown of the costs of this implementation, showing not only the individual cost elements of a measure (e.g. a capital cost of new equipment), but also how the total costs of implementation would vary by Member State and vary in terms of occurring at the farm or slaughter scale. The effect of a combination of measures is expressed as a percentage reduction in incidence in poultry meat, and also in the number of DALYs saved by Member State. Combining this with the costs, the tool can then display the cost per DALY saved.

(ii) Secondly the tool can **identify which combination of control methods provides a chosen target reduction in campylobacteriosis** across a chosen area at the lowest cost. The user is able to select an area (single Member State, multiple Member States, EU-wide), and the percentage reduction in campylobacteriosis incidence they wish to achieve. The model will then calculate which combination of interventions applied across the selected area will provide the target percentage reduction at the lowest cost. This combination will then be displayed to the user. The detailed breakdown of costs and benefits for this combination is also displayed.

The model considers combinations of control measures in a multiplicative manner, but also considers some methods to be mutually exclusive with each other. This is due to the real world practical issues regarding the implementation of them in combination, for example hot water treatment and freezing. Where methods are mutually exclusive the model does not allow an invalid combination to be selected.

# 3 Broiler sector profile

This section provides a summary profile of the EU's broiler meat industry, setting the context for the qualitative (and quantitative where possible) assessment of the magnitude of the impacts of the assessed measures provided later in the report. The analysis presented here is based on the most recent statistics extracted from various Eurostat databases. More detailed data are presented in Annex 3.

## 3.1 Broiler meat consumption

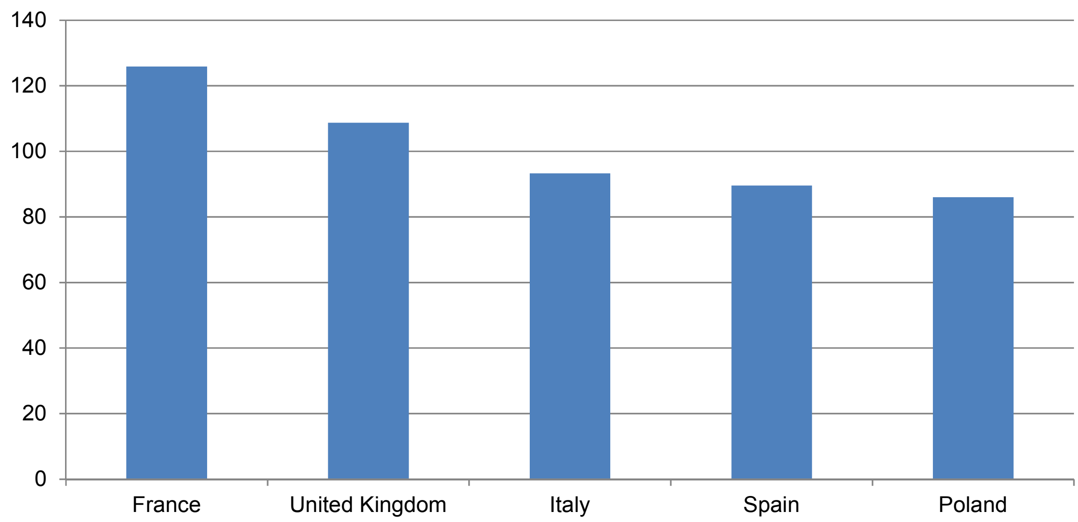
In 2010, the total level of poultry meat[6] consumption in 17 EU MS[7] was over 6.1 million tonnes. Among the EU MS for which data are available, Germany, France and Italy are the countries with the highest level of chicken meat total consumption. In 2010, they consumed 1.57 million tonnes, 1.53 million tonnes and 1.2 million tonnes respectively. The most recent Eurostat statistics on gross apparent consumption of chicken meat are presented in more detail in Annex 3 to this report.

## 3.2 Structure of the sector

This sub-section presents an overview of the structural and economic characteristics of the broiler sector statistics describing the structure and economics of the broiler meat sector, including farming and slaughter.

In 2007 broilers were being reared in 3.3 million agriculture holdings in the EU, of which 2.1 million (or 66%) were (most micro scale holdings) in Romania. The 2007 data estimate the broiler population at 794 million. France, Italy, the UK, Spain and Poland had the largest broiler populations. Their share of total EU broilers ranged from 16% (France) to 11% (Poland). Figure 3.1 shows the broiler population figures for these countries.

**Figure 3.1 Number of broilers in agricultural holdings in top 5 EU MS in 2007 (in millions)**




*Source: Eurostat*

Taking into account both indoor and outdoor reared birds, approximately 6 billion chickens were slaughtered in 2010 in the EU27, with an aggregate slaughter weight of 9.5 million

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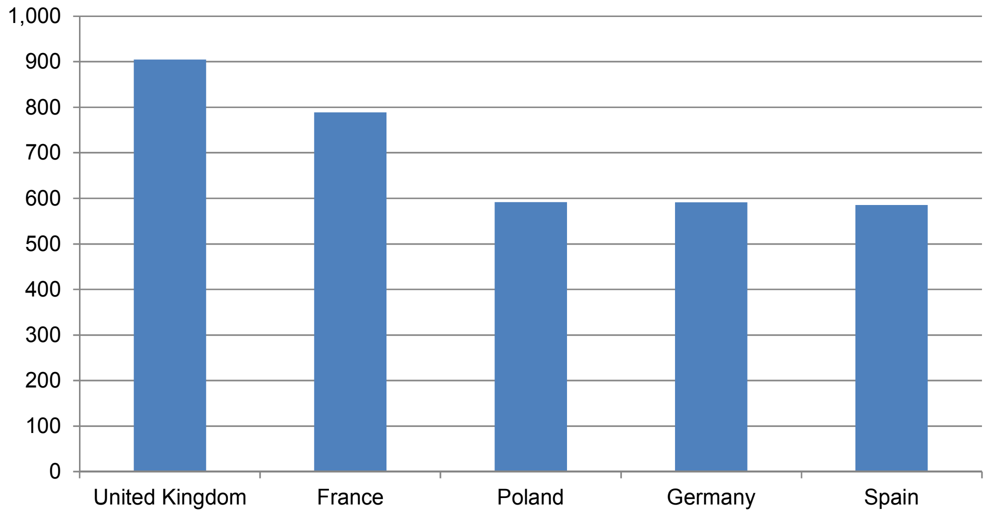
[6] Poultry meat includes: cocks, hens and chickens; turkeys; ducks; geese; and guinea fowl.

[7] The aggregate figure includes the EU MS for which there are statistics in 2010, the most recent time with available data. For the EU MS for which 2010 data are not available, previous most recent available figures (i.e. either 2009 or 2008) have been used to calculate the aggregate figure. EU MS for which no data are available for any of these years are excluded from the calculation.

tonnes. 70% were slaughtered in one of five Member States – the UK, France, Poland, Spain and Germany (Figure 3.2).

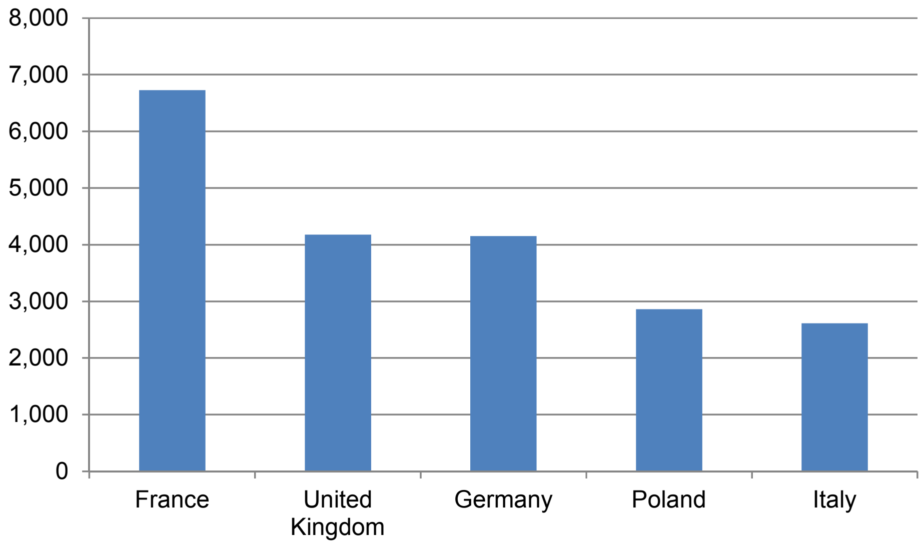
**Figure 3.2 Number of chickens for slaughtering in top 5 EU MS in 2010 (in millions)**




*Source: Eurostat*

In 2008, there were an estimated 2,243 enterprises operating in the production and preservation of poultry meat, 14% higher than in 2007. These enterprises employed an estimated 150,475 people in 2008 (a 5% gain on the previous year). The total value of the sector increased from €26.7 billion in 2007 to over €29.8 billion in 2008. France, the UK, Germany, Poland and Italy had the highest turnover, with shares ranging from 23% (France) to 9% (Italy) (Figure 3.3).

**Figure 3.3 Market turnover in production and preserving of poultry meat in top 5 EU MS in 2008 (€ million)**




*Source: Eurostat*

## 3.3 EU production

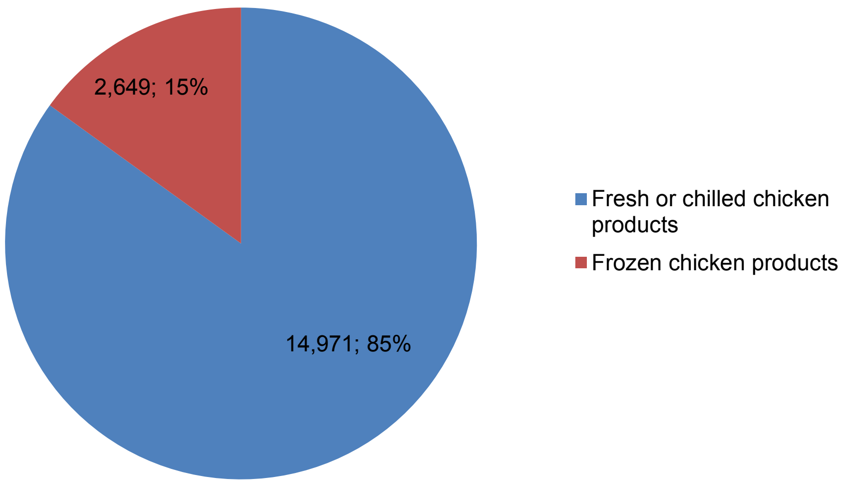
In 2010 EU chicken meat production in the EU was valued at approximately €18 billion (Eurostat). The aggregate figures include the following product categories:

- Fresh or chilled whole chickens;
- Fresh or chilled cut chickens;
- Frozen whole chickens; and
- Frozen cut of chickens.

The production of fresh or chilled chickens dominates the EU broiler sector. In 2010, the total value of fresh or chilled chicken production, either as a whole chicken or in pieces was €15 billion (85% of the EU market). In the same year, frozen chicken products accounted for 15% of the market (Figure 3.4). Cuts of chicken products now have a greater market share than whole birds (Figure 3.5).

**Figure 3.4 EU chicken meat production was worth around €17.6 billion in 2010**

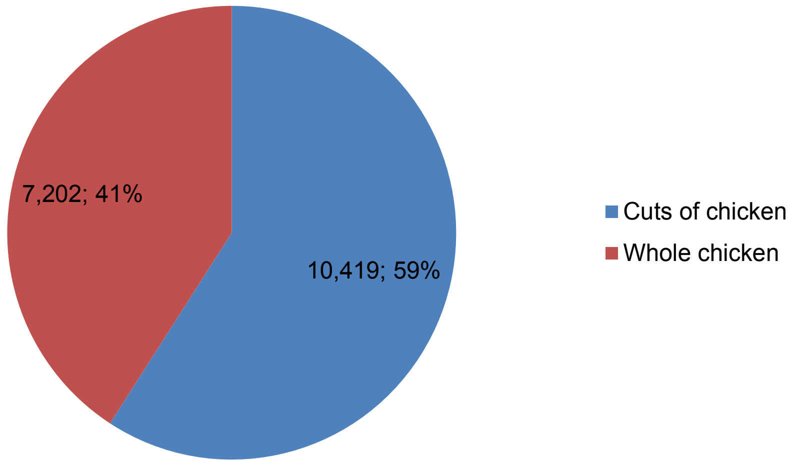
*The value (€ million) and the share (%) of fresh/chilled and frozen chicken products in the EU production (2010)*




*Source: Eurostat*

**Figure 3.5 There is more value in cuts of chicken than sale of whole birds**

*The value (€ million) and the share (%) of cuts of chicken and whole chicken products in the EU production (2010)*




*Source: Eurostat*

Including both fresh and chilled and frozen products, five Member States account for approximately 60% of the EU market. In 2010, the UK had a share of 15% of EU broiler meat production, followed by France (13%), Spain (12%), and the Netherlands (10%). Germany (10%) was the fifth biggest EU MS in chicken production in the same year[8].

## 3.4 Trade

In 2011, EU internal trade in and external imports of chicken products totalled over 5 million tonnes and €4.6 billion in value. In 2011 the value of intra-EU imports increased by 11% from the previous year, while the increase in quantity in the same period was 138%. Imports to the Netherlands increased from 3,500 tonnes to over 31,000 tonnes in 2011. In the period 2010-2011, extra-EU imports increased 13% by value and 4% by volume.

The data presented in this sub-section have been extracted from Eurostat Comext database, Harmonised System at 6 digit level (HS6).

EU trade analysis includes four product categories:

- Fresh or chilled fowls of the species *Gallus domesticus* (not cut in pieces);
- Fresh or chilled cuts and edible offal of fowls of *Gallus domesticus*;
- Frozen fowls of *Gallus domesticus* (not cut in pieces); and
- Frozen cuts and edible offal of fowls of *Gallus domesticus*.

To be compatible with the previous sub-section, in the rest of the sub-section (both in the text and in figures) these products will be used interchangeably with the following product names respectively

- Fresh or chilled whole chickens;
- Fresh or chilled cut chickens;
- Frozen whole chickens; and

[8] The statistics have been extracted from Eurostat Prodcom database and analysed by the evaluation team. The data summaries are presented at a more detailed level in Annex 3.

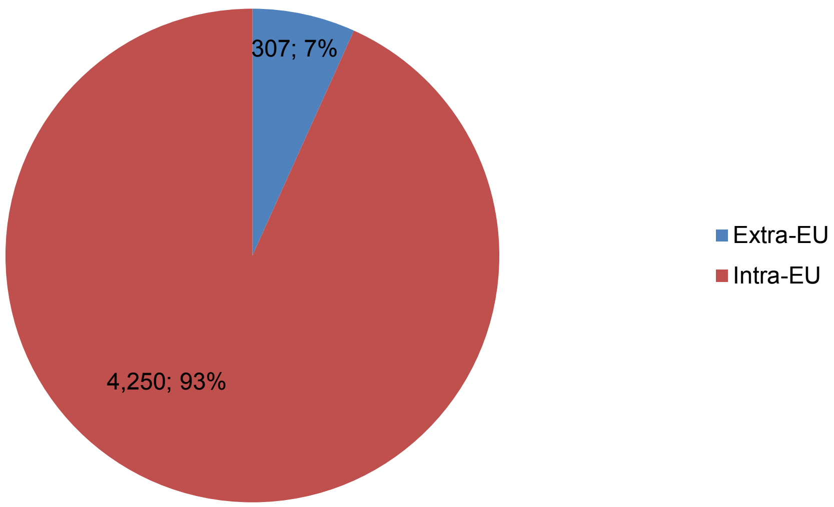
- Frozen cut of chickens.

### 3.4.1 Imports

The trade of chicken products within the EU is much larger than imports to the EU from third countries. In 2011, approximately 93% of EU27 broiler product imports came from another EU Member State. Extra-EU imports for selected product categories had a share of 7% in the same year (Figure 3.6).

**Figure 3.6 EU imports of chicken products were worth around €4.6 billion in 2011 and largely dominated by the internal trade**

*The value (€ million) and the share (%) of extra-EU and intra-EU imports in 2011*

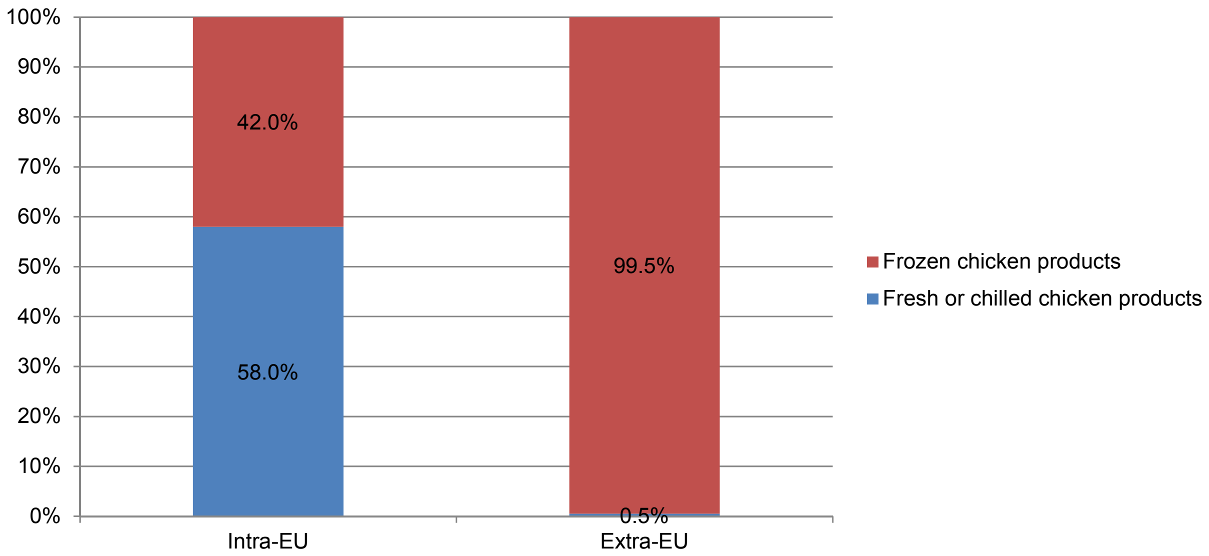



*Source: Eurostat*

Fresh and chilled products dominate intra-EU trade of chicken products. In 2011, 58% of the broiler products traded within the EU were fresh or chilled; 42% were frozen products.

The extra-EU chicken meat trade mostly consist of frozen products. In 2011, only 0.5% of the extra-EU imports were fresh or chilled chicken products while 99.5% were frozen (Figure 3.7).

**Figure 3.7 Share of fresh or chilled and frozen chicken products in EU imports (2011)**

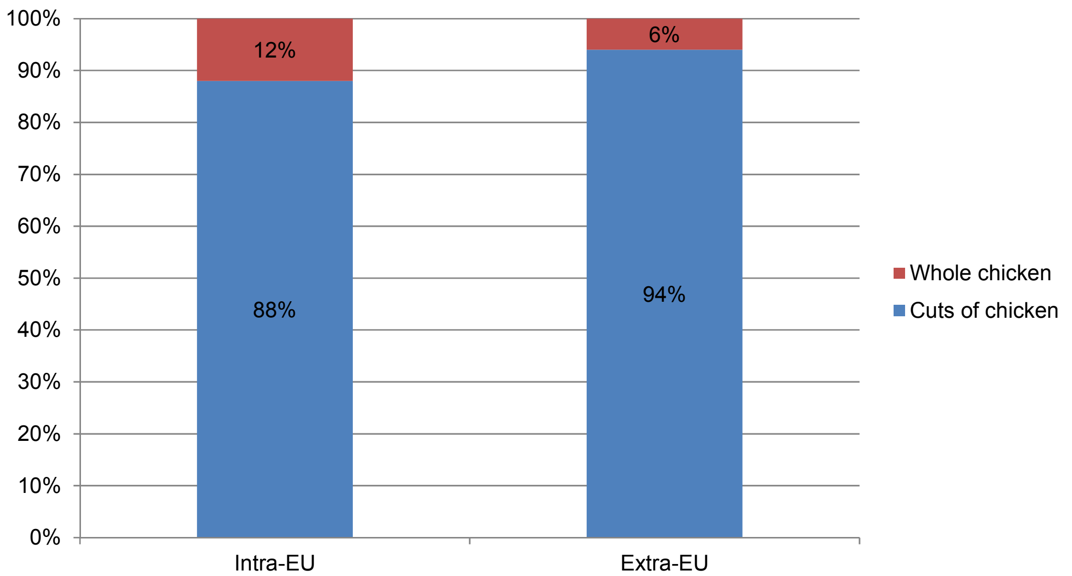



*Source: Eurostat*

In terms of the type of products, intra-EU trade and imports from third countries are dominated by cuts of chicken. The share of cuts of chicken was 88% (€3.7 billion) in intra-EU trade and 94% (€289 million) in extra-EU imports in 2011. The figures are presented in Figure 3.8 .

**Figure 3.8 The value of cuts of chicken exceeds that of whole birds sold**

*The share (%) of cuts of chicken and whole chicken products in the EU imports (2011)*

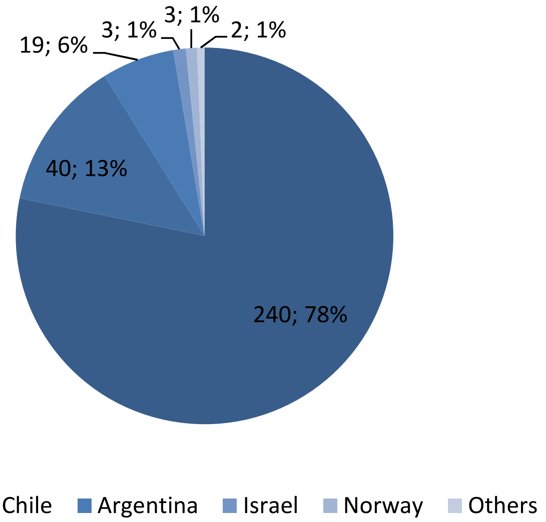



*Source: Eurostat*

The main external sources of broiler products imported into the EU are Brazil, Chile and Argentina. These three countries together accounted for about 97% of the total extra-EU imports in 2011.

**Figure 3.9 The value of total extra-EU imports in 2011 was about €307 million and main trade partners, Brazil, Chile and Argentina formed 97% of the extra-EU imports**

*The value (€ million) and share (%) of extra-EU imports of chicken products with major partners (2011)*



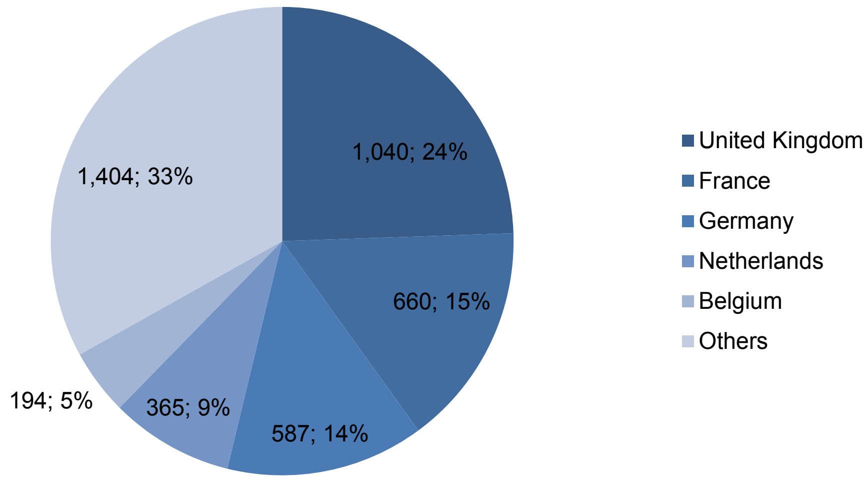

*Source: Eurostat*

The Netherlands, Spain, the UK, Germany and France are the main points of entry for imports into the EU. The share of these MS in total extra-EU imports in 2011 ranged from 43% (NL) to 3% (FR).

Analysis of data on the EU's internal market shows that the UK, France, Germany, the Netherlands and Belgium were the main importers of chicken products from other Member States. In 2011 the total value of intra-EU imports by these countries was over €2.8 billion, representing 67% of the €4.25 billion total internal trade in these products (Figure 3.10).

**Figure 3.10 In 2011, five Member States accounted for 67% of the €4.25 billion value of intra-EU trade in chicken products, expressed in terms of imports**

*The value (€ million) and share (%) of intra-EU imports of chicken products in top 5 EU MS (2011)*




*Source: Eurostat*

The Netherlands, Germany, Belgium and Poland are the major exporters with the EU market. Table 3.1 presents a summary of major intra-EU importers with their trading partners in 2011, in terms of the value of imports for chicken products.

The Netherlands exports chicken meat products mostly to the UK, France, Germany and Belgium. Except France, the Netherlands is the main trade partner of the selected EU MS.

**Table 3.1 Top 3 partners of the major intra-EU importers (2011) ***

| Importing country | | Principal EU trading partners | |
|---|---|---|---|
| **UK** | NL (54%) | IE (14%) | PL (11%) |
| **FR** | BE (29%) | NL (29%) | DE (17%) |
| **DE** | NL (54%) | PL (10%) | AT (8%) |
| **NL** | BE (41%) | DE (23%) | UK (12%) |
| **BE** | NL (59%) | FR (22%) | DE (9%) |

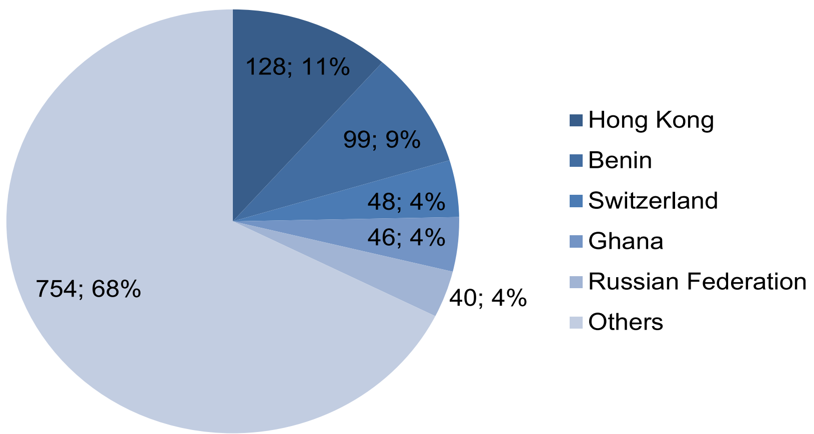
*Source and notes: Eurostat*

**Percentages in parenthesis indicate the share of trade with a particular partner in total value of imports undertaken by the importer.*

### 3.4.2 Exports

The EU exports chicken products to third countries.  The principal export markets for EU are Hong Kong, Benin, Switzerland, Ghana and the Russian Federation. The aggregate value of the selected export products towards these trade partners was €361 million in 2011. This was approximately 32% of total EU exports for these product categories (Figure 3.11).

**Figure 3.11 Major export partners for EU chicken products in terms of value (€ million) and share (%) of trade in 2011**




*Source: Eurostat*

# 4 The benefits of *Campylobacter* control

## 4.1 Introduction

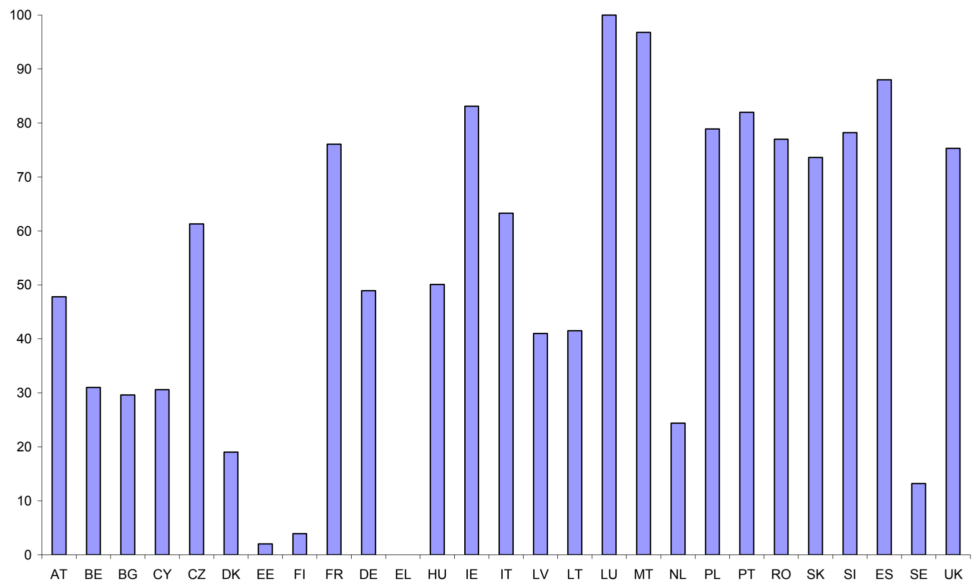
The principal societal benefit of better control of *Campylobacter* in the broiler supply chain is a reduction in the infectious intestinal disease (IID) burden on humans. This section considers the component pieces of evidence and analysis required to establish the benefits of any particular control strategy. Specifically it:

- Provides information on the prevalence of *Campylobacter* in the broiler supply chain;
- Reports evidence on the human health burden attributable to *Campylobacter* in broilers;
- Considers the implications of evidence on the scale and character of the direct and indirect transmission mechanisms linking *Campylobacter* prevalence in the supply chain to human health burdens for the modelling of the benefits of control strategies;
- Explains the approach adopted to estimation of benefits; and
- Clarifies the proposed targets for an EU *Campylobacter* control strategy in the context of the above.

## 4.2 Prevalence of *Campylobacter* in broilers

This section details the statistics on prevalence of *Campylobacter* in the broiler sector across the EU27. An EU-wide baseline survey was carried out at slaughterhouse level to determine the prevalence of *Campylobacter* in broiler batches and carcasses thereof in accordance with Decision 2007/516/EC[9]. The results were published by the European Food Safety Authority (EFSA) in October 2009. At EU level the prevalence of *Campylobacter*-colonised broiler batches was 71.2% and that of *Campylobacter*-contaminated broiler carcasses was 75.8%. Member State prevalence varied from 2.0% to 100.0% and from 4.9% to 100.0%, for caecal contents and carcasses, respectively[10]. Figure 4.1 illustrates the observed prevalence of *Campylobacter* in poultry meat as reported in the research commissioned by EFSA. It demonstrates the large variation across the EU.

**Figure 4.1 Prevalence of *Campylobacter* in poultry meat % (EFSA, 2010a)**



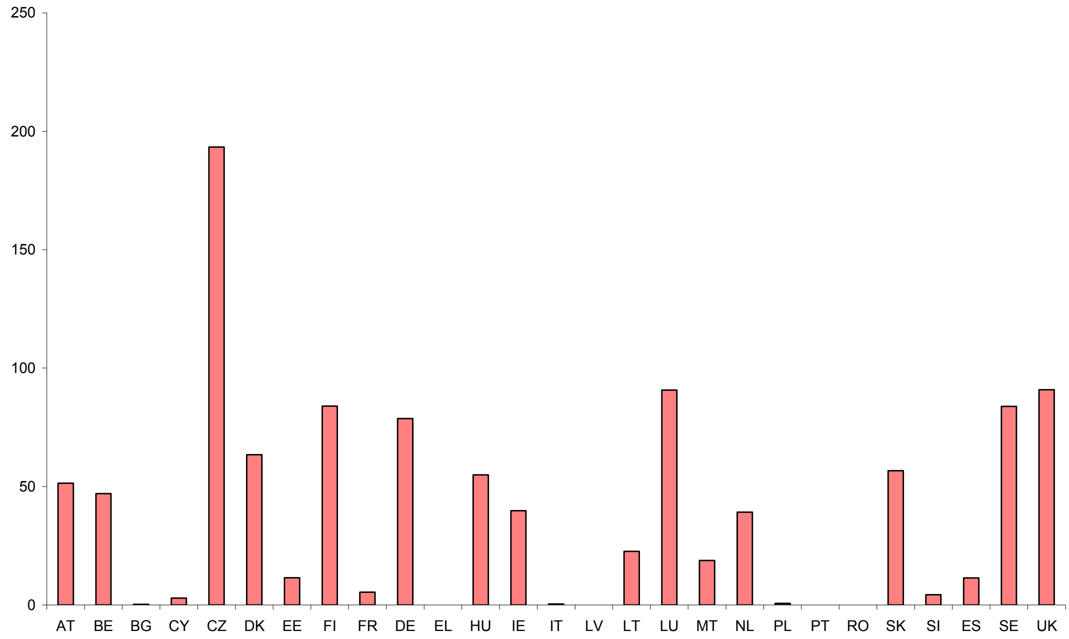

[9] OJ L 190, 21.7.2007, p. 25.

[10] *The EFSA Journal* 2010, 8(03):1503

## 4.3 Campylobacteriosis cases attributable to *Campylobacter* in broiler production

The notification rate of campylobacteriosis cases (expressed as confirmed cases per 100,000 population) for the EU 27 countries as reported by EFSA (EFSA, 2010b) is shown in 0. It suggests significant variation in prevalance and/or reporting across the EU. EFSA noted that,"the variation in the notification rates of campylobacteriosis cases among reporting MSs is large and the different sensitivities of the reporting systems and microbiological methods employed by MSs may have influenced these figures; consequently comparison between countries should be carried out with caution".

**Figure 4.2: Human notification rate (confirmed cases per 100,000 population) (EFSA, 2010b)**



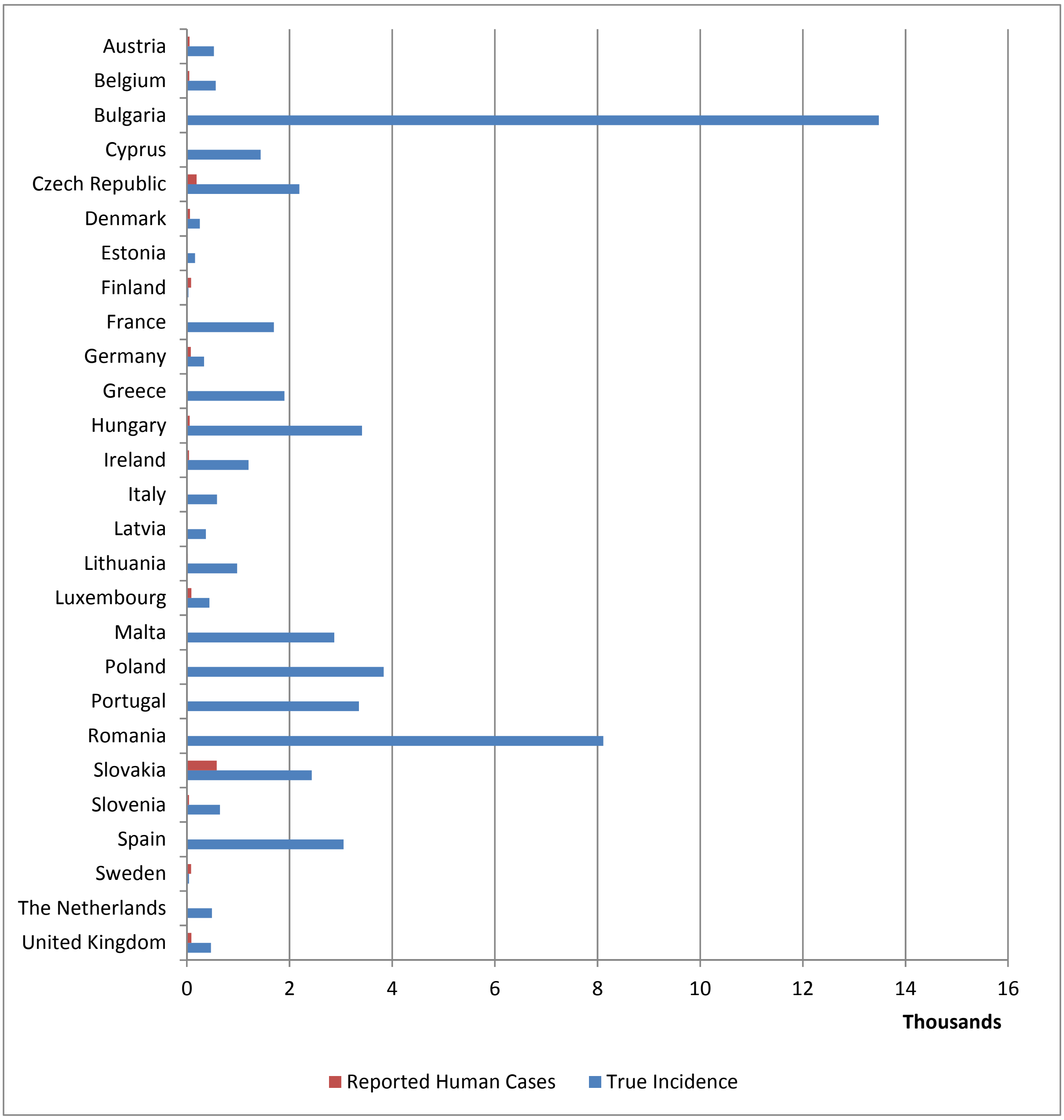

The EFSA 2011 Scientific Opinion estimated that for the EU27, the true incidence of campylobacteriosis was approximately 9.2 million cases per year (90% CI [3.3; 20]). It estimated that only 2.1% (90% CI [0.8; 5]) of all cases are currently reported. The EFSA analysis suggests that reported cases represent only a fraction of actual disease burden (Fig 4.10).

On the basis of the incidence estimates and a previous estimate of disease burden and costs, the 2011 EFSA Opinion considered that the public health impact of campylobacteriosis is around 0.35 million disability-adjusted life years per year for the EU-27. The annual cost is estimated at about €2.4 billion.

There is little peer-reviewed research evidence explaining the proportion of IID cases that are caused by *Campylobacter* for most MS. The proportion of cases of campylobacteriosis attributable to the consumption or handling of *Campylobacter*-contaminated broiler meat in each MS is not well established.

Based on limited Dutch data and the extrapolation of international data, it has previously been estimated that poultry is responsible for, at the most, 40% of all human cases of campylobacteriosis (Havelaar, 2002). A recent large-scale case-control study in the Netherlands indicates chicken meat to be responsible for at least 20% of all cases of human *Campylobacter* infections (Doorduyn et al., 2005). From such information, the EFSA Scientific Opinion on quantification of the risk posed by broiler meat to human campylobacteriosis in the EU concluded that, "*Handling, preparation and consumption of broiler meat may account for 20% to 30% of human cases of campylobacteriosis, while 50% to 80% may be attributed to the chicken reservoir as a whole*." (EFSA 2010a).

**Figure 4.2 Comparison of report and the estimated actual incidence rates of campylobacteriosis (cases for 100,000 population)**




Source: date sourced from EFSA (2011)

This suggests two mechanisms that connect *Campylobacter* in chickens with cases of campylobacteriosis in EU's human population:

1 A direct transmission route mediated through the broiler supply chain in consumers handling, preparing and consuming contaminated meat;

2 An indirect transmission route linking *Campylobacter* in the 'chicken reservoir' and the human population.

## 4.4 Implications for the estimation of the reduction in disease burden associated with *Campylobacter* control measures

This section considers the implications of the scientific evidence summarised for the modelling of the reduction of campylobacteriosis prompted by the control options and strategies considered in this study.

### 4.4.1 General approach

The benefits of *Campylobacter* control in broiler production are translated into benefits for society through reduction of related human illness. The process for calculating the benefits derived from reducing *Campylobacter* prevalence in the EU broiler sector involves:

- Identifying the current number of total campylobacteriosis cases at MS and EU level in the baseline;
- Estimating the proportion of campylobacteriosis cases which are the result of *Campylobacter*-infected meat from the broiler sector – as this is highly variable between MS, a single value will be used for the analysis;
- Multiplying the number of campylobacteriosis cases attributable to *Campylobacter* -infected broiler meat by the reduction in *Campylobacter* incidence per MS and for the EU as a whole for each control measure (thereby identifying the number of campylobacteriosis cases avoided through *Campylobacter* control measures in the broiler sector across the EU and for the EU as a whole);
- Deducing the benefits to society by applying disability adjusted life years (DALY) to the number of campylobacteriosis cases foregone through application of the *Campylobacter* control measures using a single estimate from the EFSA Opinion.

It is sufficient to disregard imports of poultry meat as these are largely frozen and freezing is itself an effective *Campylobacter* control measure. The analysis is restricted to indoor broiler production; the farm level control measures specified for the study are not applicable to outdoor reared birds. The analysis also includes reduction in the prevalence of *Campylobacter* through measures taken at the slaughter stage whether the birds have been reared indoors or outside.

### 4.4.2 Supply chain transmission

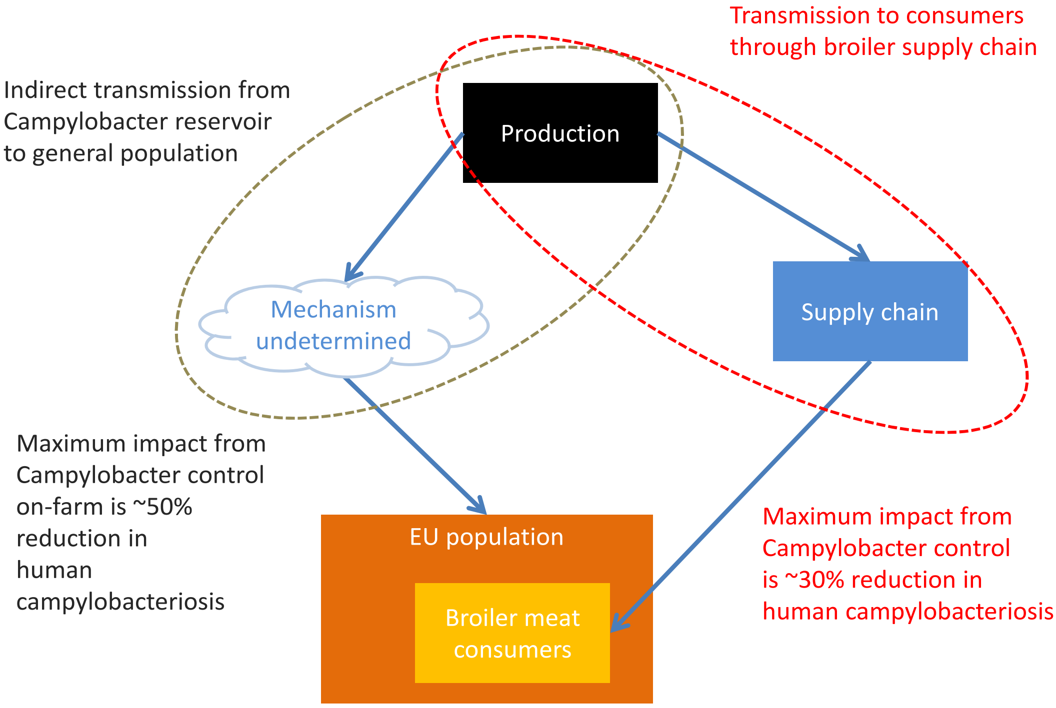
For the purposes of this study it is assumed that 30% of campylobacteriosis cases result from the handling and consumption of (*Campylobacter*) contaminated chicken meat. Under this assumption, the ‘prize’ on offer from fully effective eradication of *Campylobacter* from the broiler supply chain is therefore a reduction in case load equivalent to at least 30% of the total estimated current cases of campylobacteriosis.

### 4.4.3 Indirect transmission

The evidence (EFSA, 2011) suggests that reduction of the *Campylobacter* reservoir on poultry farms would yield human health benefits beyond those attributable to *Campylobacter ‘transmitted’* through the handling and/or consumption of poultry meat alone. However, the pathway(s) by which such benefits are obtainable is, as yet, undetermined but likely to be environmental.

It is expected that the greatest benefits would result from measures applied at the farm level to reduce the prevalence of *Campylobacte*r-positive flocks because this would have an effect on environmental contamination. Nonetheless, consultations with the team’s scientific advisors suggest that while defensible assumptions can be made in the model with regard to food supply chain effects, the presence of this additional ‘reservoir’ effect should be noted but it would not be appropriate to attempt to quantify such additional indirect health benefits from individual control options.

**Figure 4.3 Reducing the size of the 'reservoir' of *Campylobacter* in the broiler population may reduce human illness through pathways other than the broiler supply chain, though the transmission routes are not, as yet, determined.**




## 4.5 Control strategy targets

The above discussion has important implications for the target reductions as specified in the study terms of reference. These suggested that a new EU strategy for the control of *Campylobacter* in broilers would be formulated with reference to targets of (a) a 50% and (b) a 90% reduction in human campylobacteriosis.

Clearly, actions in the broiler sector cannot reduce cases of human campylobacteriosis that are attributable to other sources of infection. The assumption therefore is that the target reductions used in this study should relate to the fraction of directly-attributable human campylobacteriosis - i.e. 30% according to the discussion above and Figure 4.8. This suggests that elimination of all direct transmission through the broiler supply chain could avoid up to 2.76 million cases a year.

A 90% reduction would thus see attributable cases fall from 2.76 million to 276,000 per year, and a 50% reduction see attributable cases fall to 1.38 million cases. As noted above, on-farm control measures that resulted in reduced flock prevalence would be expected to result in some, possibly significant, additional benefits associated with reducing the reservoir, but these cannot be quantified.

The analysis provided here provides estimates of the costs of alternative combinations of approaches that could, based on available estimates of their efficacy, achieve the 50% or 90% target.

## 4.6 Approach to valuation of the benefits of additional Campylobacter control in broiler production

This section explains the approach adopted for valuation of the benefits of the control measures considered in the study.

### 4.6.1 Valuation of health benefits

The approach adopted for valuing the benefits from reduced *Campylobacter* in poultry and proportionate reduction in human illness is based on the Cost-Utility study by Mangen et al (2007) which expressed the reduced disease burden in disability-adjusted life years (DALYs) avoided. A single DALY value of 0.039 DALYs per human case of campylobacteriosis has been used, based on the EFSA Opinion estimate of nine million cases of human campylobacteriosis per year in the EU27 representing 0.35 million DALYs per year. In monetising the DALYs, a single value is used across all MS, again based on the data reported in the EFSA Opinion (disease burden of campylobacteriosis 0.35 million DALYs per year and total annual costs are 2.4 billion €).

### 4.6.2 The impacts of trade

One important aspect in this calculation of campylobacteriosis cases avoided is the fact that, in practice, a proportion of this human disease is related to the handling and consumption of poultry meat while the estimation of costs at the Member State level is based on the reduction of *Campylobacter* colonisation/contamination during production. Differences between consumption and production at the MS level, due to intra-EU trade and external trade flows of fresh broiler meat, mean that costs and benefits may not be proportionate.

Given that the purpose of this study is to inform EU-level action, it is not helpful or relevant to consider the distribution of costs and benefits between MS due to trade. Thus, the model uses a consistent basis for both costs and benefits, namely the MS meat production statistics. However, it is important to remember that some countries will benefit disproportionately (i.e. net importers of poultry meat from other Member States) and others will bear a greater share of the costs (i.e. net exporters of poultry meat).

# 5 The control measures considered

This section briefly introduces the control measures considered in the study. Each intervention is described in more detail in Annex 4.

Intervention measures to prevent the transmission of *Campylobacter* from poultry meat to humans can be applied at various points in the food chain. EFSA (2011)[11] suggested that a multi-layered intervention strategy would be optimal, with sequential intervention approaches targeting different events in the infection route, starting on the farm and progressively moving down the supply chain.

Three main risk factors have been identified for campylobacteriosis: flock prevalence; carcass contamination; and kitchen hygiene. Food hygiene in the home is out of scope for the purposes of this study. The focus here is therefore on reducing flock prevalence and carcass contamination.

The starting point for a control strategy is to prevent *Campylobacter* from entering the live flock, through measures implemented on-farm. Biosecurity measures are considered fundamental to this, but slaughter age and the practice of partial depopulation ('thinning') of flocks are also important risk factors. If these measures are not successful, then reducing flock susceptibility to infection is the next element of the strategy. This could involve interventions such as feed or water additives and in future there is the potential for vaccination. These measures are unlikely to produce negative flocks; it is more likely that they will reduce the number of Campylobacter in the gut or perhaps the number of positive birds in a flock. If these approaches fail to prevent infection, then the aim should be to reduce the number of *Campylobacter* in the bird gut at the end of the production cycle, for example with the use of bacteriocins. Measures applied at the slaughterhouse or processing stages or during storage could provide the final intervention component before consumer-orientated factors are considered. Measures could include improved processing hygiene and carcass decontamination.

On-farm interventions would reduce not just the numbers of *Campylobacter* in the food chain but also the numbers of poultry-associated *Campylobacter* in the environment in general. This is considered to give further benefits, since EFSA (2011) reported that between 50% and 80% of human campylobacteriosis is thought to be attributable to the chicken reservoir as a whole (see section 4). This is not accounted for in the model but is referenced in the narrative where relevant.

A list of ten control measures was agreed with the European Commission for consideration in this study, as examples that could impact human campylobacteriosis, these consisting of five farm-level measures (F1-F5) and five slaughterhouse measures (S1-S5) as follows:

F1 - Enhanced Biosecurity

Adoption of a package of additional measures as examples to complement existing accepted minimal biosecurity measures (defined in Annex 4) to prevent *Campylobacter* entering the flock. These additional measures to include:

a) The use of house-specific footwear and clothing,

b) Provision of dedicated changing facilities

c) External training for farm managers on biosecurity and internal training conducted by farm managers for stockmen.

The introduction of fly screens for houses is a potential measure in addition to the enhanced biosecurity package but is not costed in this analysis.

F2 - Early

Slaughter age reduced from 42 days to 35 days. Earlier slaughter accounts in large part for the lower positive flock prevalence in

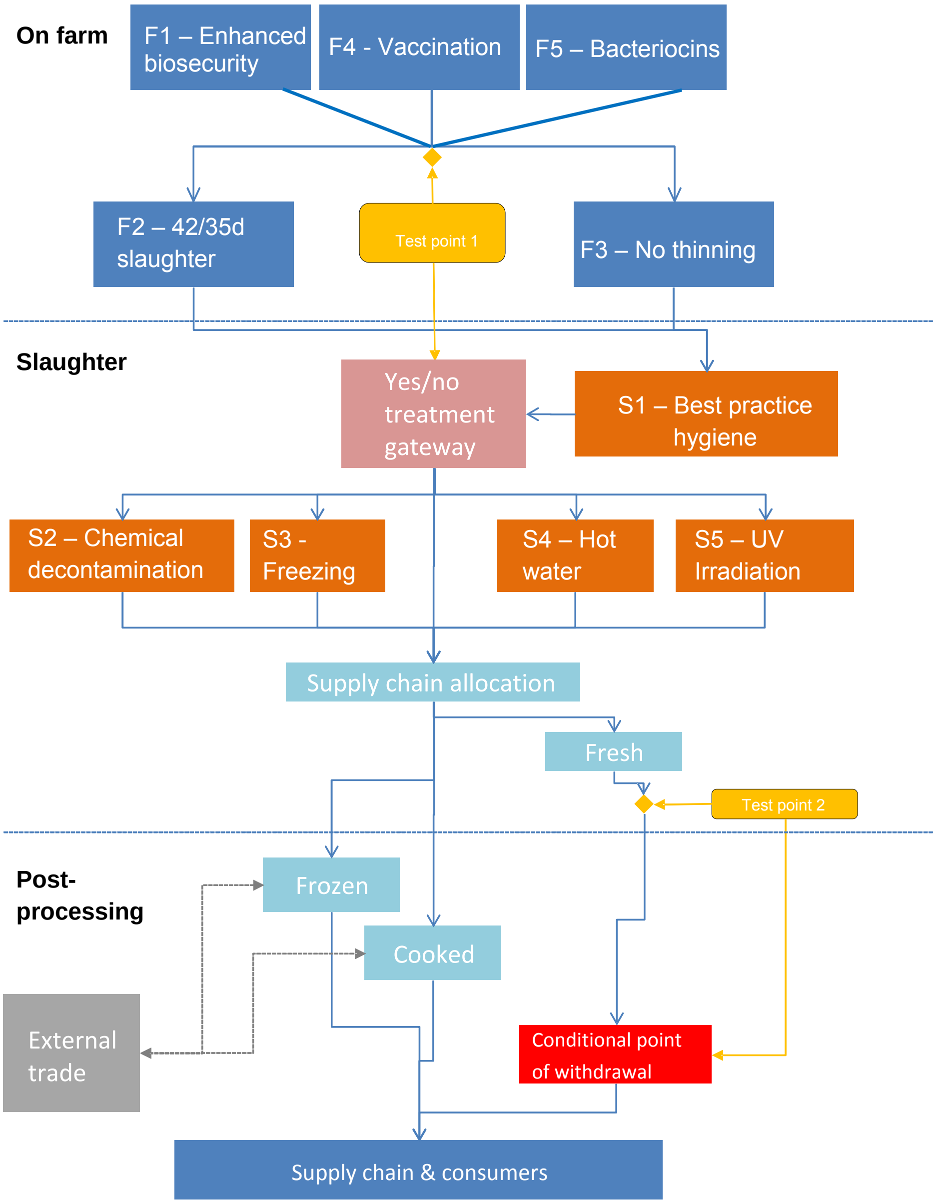
| | |
|---|---|
| slaughter | Scandinavia (EFSA, 2011). |
| F3 – No thinning | Discontinue the practice of flock thinning (defined in this study as the removal of 25% of a flock at day 35, followed by full depopulation at day 42). |
| F4 - Vaccination | The use of live or killed vaccines to reduce or prevent *Campylobacter* colonisation. |
| F5 - Bacteriocins[12] | Reduce the number of *Campylobacter* in the bird gut at the time of harvest by dosing with bacteriocins (SRCAM 602, OR-7, E-760 or E50-50) just before slaughter (EFSA, 2011). Note that similar effects are potentially observable by the use of bacteriophages (EFSA, 2011). |
| S1 - Best practice hygiene | Modern processing equipment and better trained/motivated staff |
| S2 - Chemical decontamination | Decontamination of the carcass by dipping in a solution of 2.5% lactic acid / 10% trisodium phosphate (TSP). |
| S3 - Freezing | Carcass is frozen for 2-3 weeks at -20°C at off-site specialist facilities. Off-site freezing is assumed by Mangen *et al*, 2005. |
| S4 - Hot water | The application of steam to the carcass at atmospheric pressure for 24 seconds at 90°C (Whyte *et al*, 2003). |
| S5 - Irradiation | A processing technique that exposes food to gamma rays to inactivate *Campylobacter*, both on the surface and within the meat. Off-site irradiation is assumed (Mangen *et al*, 2005). |

Figure 5.1 shows the map of control measures in the context of the broiler meat supply chain. The options are implemented at three discrete stages in the supply chain: pre-harvest (on-farm), post-harvest (at the slaughterhouse/processing stage) and then a post-processing testing and withdrawal system (recognising that the testing may in practice take place at the processing plant).

Specification and costings have been considered for the two testing points in the supply chain. These are component elements of any control strategy. At present T1 and T2 are forced into the model results, as they are seen as the basis for ensuring effective implementation of controls at both farm and slaughtering.

[12] A bacteriocin is an antibacterial substance produced by a strain of bacteria and harmful to another strain within the same family.

**Figure 5.1 Interventions map**



# 6 Intervention appraisal

## 6.1 Introduction

This section presents the results of the costing analysis. In order to provide a comprehensive and balanced appraisal of the control options, each option is assessed by reference to a number of criteria. They are intended to reflect not only the likely effectiveness and cost of controls, but issues of practicality and acceptability. These criteria are discussed briefly below before each of the controls is considered in turn.

## 6.2 The assessment criteria

### 6.2.1 Industry uptake

The scope for implementing controls in future is constrained by the extent to which there is existing uptake in the baseline position and also the maximum potential uptake possible. These data are significant insofar as scale of uptake is important in delivering the step change sought in reducing *Campylobacter* flock prevalence. Where the control is mandated, there will be both public and private costs of doing so and this should be proportionate to the benefits realised; where uptake is limited at present, the control may not offer value for money.

While the model can accommodate baseline and maximum uptake data at MS level, data are not generally available. Where data are absent, estimates of EU baseline and maximum uptake have been used. We have used some broad rules to differentiate the baseline and maximum uptake of key measures across MS as follows:

- F1 – where the MS incidence of Campylobacter is very low (<25%), we have set the baseline to 50% uptake of Enhanced Biosecurity on the assumption that there is already good levels of practice in these MS; otherwise the baseline is set at 10%.
- F2 – where MS average days to slaughter is very low (<38 days), we have set the maximum uptake to 50% uptake of Early Slaughter; otherwise it is set at 95% (or 75% for France due to the extent of outdoor-reared systems).
- F3 – where the MS has already banned Thinning, as is the case in Sweden, the baseline is set to maximum uptake.

We use a denominator of ‘all broilers’ rather than ‘broilers housed indoors’ throughout this analysis. Robust data for the latter are not available at MS level but we have assumed 5% of all poultry are outdoor-reared or finished in all MS except France where we assume the level is 25%. This equates to an EU figure for housed broilers of 92%.

### 6.2.2 Efficacy of controls

It is accepted that the potential interventions vary greatly in their effectiveness and in their ease of practical application.  The efficacy figures used in this analysis reflect the range of effectiveness set out by EFSA (2010). This is not only important in highlighting the bounds of possible reduction of *Campylobacter* flock prevalence (and associated cost-effectiveness) *per se* but also indicates the reliability of the control from a policy perspective.

While in practice, the efficacy of given controls may depend on the climatic conditions, season and production practices in a given MS, common estimates are assumed to apply in the absence of better data.

### 6.2.3 Cost of implementation

The cost of implementing *Campylobacter* controls will vary by business (producer and processor) within and across countries, based on the scale of operation (economies of scale) and established practice. Given the other uncertainties in this analysis, notably in uptake and efficacy, we have estimated a single point cost as a central estimate for the nominal EU business in order to calculate cost effectiveness rather than try to gauge the potentially vast range of costs which might apply in practice across all circumstances. Where possible we have allowed for variation in labour costs by MS and also for key resources, such as electricity and water, using published data from Eurostat. The data deployed are described in Annex 6.

The rationale is that it is the high-level average cost of implementing one control in comparison to another that is important, rather than representing the full cost range. **It is important that the analysis of controls is interpreted in this light rather than as absolute.** For this reason, cost of implementation is shown as a range of +/- 20% from the central estimate.

### 6.2.4 Availability of controls

The selection of interventions concentrates mainly on options that are **directly available** without further research, innovation or development although some potential controls, such as vaccination are included. Certain chemical decontamination options for carcasses are included within the controls considered, although it is accepted that these would require approval since they are not currently authorised within the EU.

A system of 'traffic-light' scoring is used to flag up issues of availability at this point in time (2012) although policymakers should be mindful of technological progress.

### 6.2.5 Industry and consumer impacts

Some controls have specific commercial and trading implications, for example through constraining the age of slaughter or processing poultry meat to an extent that consumer demand and market value are affected. **We do not try to quantify the economic values of such impacts but rather anticipate their presence as a component of the control selection.**

In the short term, selection of controls with industry or consumer impacts will cause disruption to markets and may lead to industry restructuring or scale change as suppliers withdraw from the market or consumers seek alternative product. Again, while it is beyond the scope of this project to anticipate the extent or social cost of such impacts, it is crucial that policymakers are aware of their potential and plan accordingly (see Chapter 8).

A system of traffic-light scoring is used to indicate the extent of possible impact on industry and consumers, although addressing *Campylobacter* flock prevalence and/or carcass contamination should ultimately increase consumer confidence and support market growth.

## 6.3 On-farm measures

### 6.3.1 Enhanced Biosecurity (F1)

'Biosecurity' refers to measures that are intended to protect the health of livestock, by preventing the transmission of disease through physical barriers and hygiene practices. Because *Campylobacter* is not vertically transmitted (Newell et al., 2011; EFSA , 2011) concluded that biosecurity measures are essential to prevent flock colonisation with *Campylobacter* and stated that if biosecurity is strictly and consistently implemented then no *Campylobacter* would be transported from outside the house to the inside. However, the EFSA report also notes that this is often not achieved in practice, because of the difficulties of establishing and maintaining the necessary biosecurity standards.

Biosecurity is widely referred to in the commercial poultry sector. It is commonly understood to comprise a 'set' of good practice measures. There are some biosecurity measures generally agreed and recommended in operation procedures established by regulators and/or the poultry industry to protect from highly infectious agents such as Newcastle Disease Virus. However, there is a lack of consensus over precisely what these measures should be to exclude *Campylobacter*, how they should be provided and what procedures should be followed. The confusion is enhanced by geographical and seasonal risk factors.

Therefore, it is inevitable that there is considerable variation between different countries/companies/sites, in terms of the biosecurity standards set and the degree to which these standards are adopted and enforced.

For the purposes of this study the baseline is defined as a minimal set of biosecurity measures as indicated in Annex 4.Several simple additional measures (dedicated changing facilities and clothing and farmer education) have then been selected which would be considered to provide 'enhanced' levels of biosecurity as examples for making estimates of costs (Annex 5). This strategy enables alternative or complementary measures to be considered in the future. Key components for the selected additional measures include the capital and labour costs of facilities and implementation and the monitoring of poultry worker hygiene procedures. Related on-farm issues such as the age of the flock at slaughter and the absence of thinning are considered separately within this report.

Table 6.1 provides a summary analysis for enhanced biosecurity.

**Table 6.1 Summary analysis of control F1 (Enhanced Biosecurity)**

| Parameter | Score | Comments |
|---|---|---|
| EU baseline uptake (%) | 10%+ | Ranges considerably both within and across MS; 10% represents a nominal allowance for units currently operating 'enhanced biosecurity' in most MS but a baseline of 50% is assumed where *Campylobacter* incidence is low (<25%). |
| Maximum potential uptake (%) | 95% | Can be applied across all housed broiler production. Maximum uptake set at 95% on the assumption that 5% of birds in EU are outdoor-reared in the EU but the France figure is exceptionally set to 75% maximum on the basis that the proportion of outdoor birds is 25%. |
| Efficacy (%) | 40 – 70% | Range based on the EFSA Opinion (Gibbens et al., 2001) of 38 – 71%. Note that this data is based on the UK only and many other EU countries have existing higher biosecurity. |
| Cost (€ per 1000 birds) | €7-11 | Enhanced biosecurity procedures are defined and costed at Annex 4 |
| Availability | High | Can be applied immediately |
| Industry impact | Low | Also likely to have additional health and performance benefits |
| Consumer impact | Low | Not visible to consumers and might be perceived to improve bird welfare. |

From the table it is clear that enhanced biosecurity is widely available, practical to implement and acceptable to consumers and it appears to be quite cost-effective as a control method. It should therefore have a role to play in reducing *Campylobacter* but there are some important issues which limit its reliability as a policy tool in the current context, namely:

- The baseline varies across the EU but this variation cannot readily be qualified and as such the scope for delivering improvement is not easy to quantify;
- Effective implementation of component measures is key to reducing infection but it would be very difficult to obtain evidence of routine adherence to protocols;

Enhanced biosecurity can be seen as a component part of a wider strategy for reducing *Campylobacter*-positive flocks where commercial incentives are in place through the supply chain. This would necessarily involve testing birds routinely on the farm just before harvesting or on arrival at the processing plant and some form of penalty for batches of birds which were *Campylobacter* positive. . The implication is that F1 will only be used with T1 (testing of birds sent to slaughter) so that there is the likelihood of an incentive for achieving higher biosecurity. Control measures F1 and T1 are not formally linked in the model and need to be selected manually in combination. T1 is detailed in Section 7.

It is pertinent to note that effective on-farm biosecurity can deliver co-benefits in terms of reduced risk of some other diseases. These have not been quantified in this study but may provide an additional incentive to producers to take up the control.

### 6.3.2 Restriction of Slaughter Age (F2)

Data from the EU baseline survey (EFSA, 2010) showed that in a multivariate analysis, the risk of *Campylobacter* colonisation increases approximately two-fold with every 10 days of age for indoor systems up to a 50 day slaughter age. During the current study, estimates of the average days to slaughter have been obtained for each Member State and it has confirmed that there are substantial variations from the mean, reflecting national differences in production systems and consumer demand (e.g. preference for heavier carcass weight). There is also variation of slaughter age within Member States (i.e. around the Member State mean) as producers produce birds to a variety of retailer and processor specifications.

EFSA (2011) reports that the prevalence of flock positivity is directly related to slaughter age and thus concludes that slaughtering at a younger age should be an effective intervention. Reducing slaughter age inevitably limits both the liveweight and the carcass weight of chickens. According to the performance objectives for one widely-used broiler chicken strain, the target liveweight for as-hatched birds at 42 days of age is 2.65kg while at 35 days, it is 2.02kg and at 28 days it is 1.41kg.

In this study, the effect of reducing slaughter age is modelled using a reduction from 42 days to 35 days (the EU average slaughter age is 41.4 days with a range from 20-150 days (EFSA, 2010)). Further reductions would increase marketing difficulties in terms of the range of carcass and portion sizes available and could result in loss of market share to non-EU countries where equivalent *Campylobacter* control measures are not in place. Any adjustment would need to be accommodated over time in order to reduce the risk of displacement of EU supply with third country imports. Such market effects are not captured in the model but are taken into account in the analysis (see Chapter 7.1).

The financial impacts of reducing slaughter age are considered in more detail elsewhere in the report, but in summary the overall annual output of chickens per building would increase, if a constant liveweight per square metre of growing space at slaughter age is assumed. This is because the number of birds placed at day-old and the number of cycles per year would be slightly higher (it is assumed that the length of the clean-out period is unchanged). The feed conversion ratio would also be improved if the growing period was reduced from 42 to 35 days but clean-out and set-up costs per year would both be higher.

Table 6.2 summarises the data located and the associated analysis.

This is a moderately effective control which has high direct costs of implementation. While in principle the control is highly available, that is all producers growing birds to 42 days or more can implement the control, the key issue is that the market demands a proportion of heavier birds. As such, producers would risk losing their markets and consumer choice would be restricted through lack of access to heavier-weight EU birds. Additionally the wide range of slaughter age within the EU means that it is difficult to apply a common control across (and within) MS.

Again, this measure should perhaps be seen as a tool for individual producers to drive down the prevalence of *Campylobacter*-positive flocks, in response to supply chain pressures to do so, and within the constraints of market demand. Any mandatory reduction in slaughter age would have significant repercussions for the sector. The specification of the age limit (e.g. as flock average, MS average, or strict cap applied to each bird) would affect the scale of those impacts. Average age at slaughter has been falling over time as breeding improves growth and feed conversion rates. The gap between the 35 day limit and average practice can be expected to reduce over time if that trend continues.

**Table 6.2 Summary analysis of control F2 (Restriction of Slaughter Age)**

| Parameter | Detail | Comments |
|---|---|---|
| EU baseline uptake (%) | 0% | Based on MS average slaughter date statistics; MS with average slaughter dates under 35 days have been assumed to comprise the baseline population. This will change with time. |
| Maximum potential uptake (%) | 50-95% | Can be applied across all housed broiler production. Maximum uptake set at 95% on the assumption that 5% of birds in EU are outdoor in the EU but the France figure is exceptionally set to 75% maximum on the basis that the proportion of outdoor birds is 25%. Where slaughter dates are lower (<38 days), the maximum potential has been reduced to 50% on the basis that this measure is not applicable to a higher proportion of flocks. |
| Efficacy (%) | 10-25% | Based on EFSA (2010). 50% reduction for 28 day limit (based on results from four countries) – assumed to be lower at 35 days. |
| Cost (€ per 1000 birds) | €50-76 | Would need to rear more birds to produce the same amount of meat, requiring investment in infrastructure. |
| Availability | High | Can be applied immediately |
| Industry impact | High | There would be significant impacts on the farm business model (production cycle will change, access to markets etc.). Additional costs associated with higher throughput not captured in the model. |
| Consumer impact | High | Would limit access to larger (older) birds potentially drawing in imports or shifting consumption patterns over time. |

### 6.3.3 Discontinue Thinning (F3)

Thinning can be defined as the partial removal of part of a flock before the end of the growing period. The practice is widely undertaken, but it is variable in terms of the percentage of birds removed during thinning and the number of days between first thin and final depopulation. If the personnel and equipment used for the thinning process are contaminated with *Campylobacter* then there is a substantial risk of transmission to the house and to the remaining flock. EFSA (2011) concluded that thinning can constitute a high risk of flock infection.

It should be kept in mind that final depopulation can also take several days and during this time the remaining birds from an initially negative flock can become positive.

The practice of thinning allows growers to optimise the use of their growing facilities and to maximise their returns per square metre of floor space. Discontinuing the practice would mean a reduction in the number of birds that could be stocked at day-old, because of the need for compliance with legal requirements on stocking density later in the growing period. Additional housing would therefore be needed to make up the deficit.

In this study, the financial effects of thinning have been assessed by comparing a regime in which 25% of the birds are thinned at 35 days, prior to final depopulation at 42 days, with a regime in which all birds are grown to 42 days and then depopulated.

Table 6.3 summarises the data located and the reliability of the data relating to the costs of potential intervention measures.

It is understood that thinning is not practiced in all EU MS (e.g. Sweden). In others, it is quite prevalent, for example more than 50% of flocks use the practice in Belgium and it is commonly used in many other EU MS.

**Table 6.3 Summary analysis of control F3 (Discontinue Thinning)**

| Parameter | Detail | Comments |
|---|---|---|
| EU Baseline uptake (%) | 25% | Common practice across most MS but varies from 0 to >50%. Assumed to be 95% in Sweden where Thinning is not practiced. |
| Maximum potential uptake (%) | 92% | Can be applied across all housed broiler production. Maximum uptake set at 95% on the assumption that 5% of birds in EU are outdoor-reared in the EU but the France figure is exceptionally set to 75% maximum on the basis that the proportion of outdoor birds is 25%. |
| Efficacy (%) | 10-25% | EFSA 2011 suggests up to 25% depending on scenarios |
| Cost (€ per 1000 birds) | €10-15 | Based on fewer birds placed at day-old and the capital cost of additional growing space. |
| Availability | High | Can be applied immediately |
| Industry impact | Moderate | Would impact differentially on companies using this practice. |
| Consumer impact | Low | No impact on consumers other than possible price rise and scarcity of smaller birds. |

The costing assumes that producers react to a ban on thinning by stocking a given production house with fewer birds but that they continue to finish them all at 42 days of age and invest in additional housing to finish the same number of birds. In practice some producers might choose to maintain bird numbers but finish them at a younger age (and lighter weight). If this were the case then option F3 is an alternative to achieve the objectives of Option F2 to some degree as slaughter age would have to be reduced. Unlike F1 and F2 it could be mandated, as in Sweden, and producers could adjust their production over a period of time.

### 6.3.4 Vaccination (F4)

According to EFSA (2011), vaccination may reduce the level of colonisation in birds or even potentially prevent colonisation by *Campylobacter* in a flock if used to support good biosecurity measures. This would reduce the number of organisms entering the food chain and the environment. At present, vaccination is not an available commercial option but proof of principle of the protective properties of *Campylobacter* antibodies has been demonstrated (Stern 1990, de Zoete 2007) especially in young birds (Cawthraw and Newell, 2010). Various different vaccination regimens and strategies have been tested but difficulties remain. These are reported to include the problem of delivering an effective vaccine to immunologically immature birds, in order to induce a rapid response from a challenge within 2-3 weeks of hatching.

Strategies are being examined for the use of both killed and live vaccines. EFSA (2011) reported that killed vaccines have so far not substantially reduced colonisation in chickens but that studies with live vaccines involving *Campylobacter* antigens expressed in *Salmonella* are more promising. However, reproducibility, safety and licensing were identified as issues still to be overcome.

Vaccination is included in this study as a possible control strategy for the future, conceivably within the 2020 threshold of this analysis, but costs can only be broadly estimated at present, because this intervention is currently at an early development stage. Similarly, the efficacy of vaccine use under field conditions, in terms of preventing flock colonisation or reducing levels of colonisation in individual birds is hard to predict at present.

Table 6.4 summarises the data located and appraisal of vaccination as a potential intervention measure.

### Table 6.4 Summary analysis of control F4 (Vaccination)

| Parameter | Detail | Comments |
|---|---|---|
| EU Baseline uptake (%) | 0% | Vaccine not yet commercially available |
| Maximum potential uptake (%) | 92% | Can be applied across all housed broiler production. Maximum uptake set at 95% on the assumption that 5% of birds in EU are outdoor in the EU but the France figure is exceptionally set to 75% maximum on the basis that there the proportion of outdoor birds[13] is 25%. |
| Efficacy (%) | 50-90% | 2 log10 reduction in caecal contents (de Zoete et al., 2007). |
| Cost (€ per 1000 birds) | €48-72 | |
| Availability | Not available | Vaccines are under development but have not yet reached the market. |
| Industry impact | Moderate | If a suitable vaccine was licensed, it could be implemented but would add cost to the industry. |
| Consumer impact | Low | Assuming safety is cleared, this should encourage consumer confidence. |

This remains an attractive option if a suitable vaccine and delivery method can be developed. In principle *Campylobacter* vaccination could be undertaken at the same time as other vaccinations to reduce incremental impacts on operator labour costs but in practice this is unlikely.

### 6.3.5 Bacteriocins (F5)

Bacteriocins are proteinaceous toxins, produced by bacteria and inhibiting the growth of other bacteria. Most bacteriocins exhibit antibacterial activity only against bacteria closely related to the producer strain but a few display broad-spectrum activity.

Limited experimental studies, from a single laboratory, have been undertaken to date with bacteriocins administered to broilers either in the feed or via the water. There is evidence that they can reduce *Campylobacter* colonisation in the chicken caecum to undetectable levels if administered 3 days before slaughter (EFSA, 2011). To date four purified bacteriocins have been demonstrated to reduce *Campylobacter* colonisation in poultry, these being obtained from three different bacteria, namely *Paenibacillus polymyza*, *Lactobacillus salivarius* and *Enterococcus* spp.

However, field validation now needs to be completed to determine the practicality of treatment in a commercial poultry environment (EFSA 2011). It is also reported that logistical issues regarding the scale-up of bacteriocin production and purification and the timeliness of application would need to be addressed. Safety may also be an issue.

Thus whilst bacteriocins are not commercially available at present, this treatment is included within the intervention options considered here with estimated product and administration costs (if via the water).

Table 6.5 provides a summary appraisal of the bacteriocins as a control measure.

[13] While vaccination may offer some level of control for outdoor-reared birds, it cannot be assumed to be at the efficacy levels used in this study and this sector is therefore excluded from our analysis.

**Table 6.5 Summary analysis of control F5 (Bacteriocins)**

| Parameter | Detail | Comments |
|---|---|---|
| EU Baseline uptake (%) | 0% | Currently in trials but not commercially available. |
| Maximum potential uptake (%) | 92% | Can be applied across all housed broiler production. Maximum uptake set at 95% on the assumption that 5% of birds in EU are outdoor in the EU but the France figure is exceptionally set to 75% maximum on the basis that there the proportion of outdoor birds is 25%. |
| Efficacy (%) | 50-90% | Assumed to be similar to Vaccination based on available literature |
| Cost (€ per 1000 birds) | €48-72 | Costly intervention due to high production cost. |
| Availability | Not available | Under development. |
| Industry impact | Moderate | If a suitable bacteriocin was licensed, it could be readily implemented but would add cost to the industry. |
| Consumer impact | Low | Assuming safety is cleared, this should encourage consumer confidence. |

Bacteriocins offer a high level of efficacy and practicality in principle but appear to be moderately expensive if used routinely in relation to other measures and crucially are not yet commercially available. The main issues are logistical, in terms of isolating a suitable bacteriocin, refining a cost-effective system for industrial production and addressing the challenges of administering near the point of slaughter.

Because bacteriocins are likely to be much more expensive than the cost of testing flocks for the presence of *Campylobacter*, it is likely that they would only be used after testing to establish whether a flock was positive or not. In this way the cost of bacteriocin treatment would only be incurred for *Campylobacter*-positive flocks. At present the model does not take account of this and assumes that, if bacteriocins are used, then they are used on all flocks. This is an issue which would need to be addressed if bacteriocin treatment were to be further developed and brought into practice."

## 6.4 Processing stage measures

There are broader benefits of controlling *Campylobacter* at farm-level, namely to avoid contamination and spread later in the supply chain and in terms of reducing the wider environmental reservoir. However, when control is not successful, it is necessary to put measures in place at the slaughter plant. The controls considered in this section are informed by the EFSA Opinion but also by experts within the team and DG SANCO.

Broadly, there are two approaches to control:

(i) Best practice hygiene to avoid cross contamination from birds which come into the plant with high levels of *Campylobacter;* and

(ii) Tactical use of controls for birds from high-prevalence flocks such as chemical decontamination, freezing, hot water treatment and irradiation.

The first control is a whole plant approach, investing in equipment, staff and processes to reduce risks; the second group involves an extra stage of processing – either on or off-site – to deal with *Campylobacter* levels above a given threshold e.g. all batches with >5000 cfu/g need to be re-called/frozen/decontaminated. The purpose of treating only highly-infected birds is primarily to minimise cost but as discussed earlier, treatment may also impact on carcass value and access to markets. On-farm testing (T1) is key to identifying birds for selective treatment.

The approach in this study and in the model does not allow for judgements on what proportion of flocks require a slaughter stage control as there are too many uncertainties. Instead it assumes that treatment is only applied to the residual population of birds affected by *Campylobacter* after farm-level controls are implemented. While this is largely consistent with the concept of tactical treatment, dealing with the population as a whole does not allow for opportunities to treat individual flocks differentially, for example diverting to the frozen meat market or to set thresholds based on *Campylobacter* counts. However, the approach of only applying controls to residual numbers of infected birds is a useful proxy.

The subsequent use of a 'Recall' approach whereby poultry which leaves the slaughter/processing plant with levels of *Campylobacter* contamination which pose a risk to public health would be taken back off the market is discussed but not modelled. This relates to the fact that the most ambitious control scenario (scenario 2) assumes 90% control so that an element of recall would apply across all strategies. There is insufficient evidence to differentiate recall costs across different strategies.

### 6.4.1 Best practice hygiene at processing plants (S1)

EFSA (2010) observed that the risk of contamination of carcasses with *Campylobacter* and of high *Campylobacter* counts on carcasses varied significantly between slaughterhouses, even when account was taken of factors such as the prevalence of *Campylobacter*-colonised batches of incoming birds. Whilst this finding may have been influenced by a range of factors, there is a strong possibility that cross-contamination could arise from other carcasses or from equipment within the slaughterhouse. This may be related to hygiene practices impacting on the extent to which caecal and faecal contents contaminate other carcasses. A number of possible causes of contamination of previously *Campylobacter*-free carcasses have been identified in previous studies. These include contaminated equipment and work surfaces, which may vary in their sensitivity to bacterial attachment and biofilm formation. The quality of the water used during processing may be important as may air quality, since several studies have identified that aerosols of *Campylobacter* are formed during defeathering. Other processes, including evisceration and chilling have also been shown to facilitate cross-contamination.

Adequate control of these risks requires the introduction of, and adherence to optimal GMP/GHP principles and process hygiene measures. FSA (2011) recommends that these must be implemented on a daily basis before additional interventions are considered at the slaughterhouse.

Habib et al (2012) investigated factors associated with *Campylobacter* contamination of broiler carcasses, using survey data collected from nine Belgian slaughterhouses in 2008. There was statistically significant variation among slaughterhouses in prevalence and concentrations of *Campylobacter* on their sampled carcasses. The correlation was investigated between the scores of official control inspections and *Campylobacter* prevalence for eight out of the nine slaughterhouses (the ninth handling free-range broilers).

The control inspections (routinely performed by the Belgian Federal Agency for the Safety of the Food Chain), and the inspection scores, were used as a general numerical indicator for the status of operational hygiene and quality of management in the slaughterhouses. Ranking of slaughterhouses based on their inspection scores was statistically correlated with their ranking based on prevalence of *Campylobacter*.

The eight slaughterhouses fell into two groups – for the first group the prevalence of *Campylobacter* ranged from 56.0-65.0% (mean 60.4%) and for the other group between 35.9-44.7% (mean 39.9%), an improvement of 34%. Perhaps of more importance, the mean % of Group A slaughterhouses which showed broiler carcass contamination with *Campylobacter* of ≥3 $\log_{10}$ cfu/g was 25.7%, but for Group B the corresponding number was 13.6%, a 47% improvement.

It was also found that the best performing plants had the newest equipment, with better hygienic design to facilitate cleaning, plus a more motivated workforce (Uyttendaele, personal communication).

Table 6.6 summarises the appraisal for this control measure.

**Table 6.6 Summary analysis of control S1 (Best practice hygiene at processing plants)**

| Parameter | Detail | Comments |
|---|---|---|
| EU Baseline uptake (%) | 10% | The standard of hygiene ranges considerably across the EU but assumed single nominal baseline uptake of 10% for frequent reinvestment in plant and staff in the absence of data. |
| Maximum potential uptake (%) | 100% | Can be applied across all slaughter facilities |
| Efficacy (%) | 20-30% | Some premises produce carcasses with both higher concentrations (≥3 log10 CFU/g) and prevalence of *Campylobacter* compared to other operators and there is an statistical correlation with poorer hygiene inspection scores, and by inference food safety management (Habib *et al*, 2012) |
| Cost (€ per 1000 birds) | €9-13 | Increased frequency of capital investment in plant and in training of operatives. |
| Availability | High | Can be applied immediately |
| Industry impact | Moderate | Additional capital cost may be prohibitive for smaller processors |
| Consumer impact | Low | This would increase retail price incrementally but should encourage consumer confidence. |

The average cost of implementation is lower than some controls but would be more expensive for small units. Key costs are the capital cost of purchasing and installing new equipment but this may also result in greater efficiencies in operation by higher line speeds and better working conditions for staff.

### 6.4.2 Chemical Decontamination (S2)

The use of chemical decontamination during processing may reduce the prevalence and numbers of *Campylobacter* on carcasses. Whilst EU legislation allows chemical decontamination treatments to be considered if a substance is shown to be safe and effective, no such treatments are currently authorised for use in the EU.

EFSA (2011) reports that a number substances have been evaluated but that there is insufficient proof at present of the effect to justify approval of any chemical. EFSA has only assessed one substance satisfactorily to date. However, chemical decontamination is included as a potential intervention measure for the future. The chemical could potentially be applied to a chicken carcass either by immersion in a solution or by a spray system.

The use of a dip tank is assumed in this study and the costs considered include the capital cost of equipment and the on-going costs of chemical, water and electricity. The latter account for around half of the total costs on a per 1000 bird basis.

Table 6.7 summarises the data located and appraisal of chemical decontamination as a control option.

**Table 6.7 Summary analysis of control S2 (Chemical Decontamination)**

| Parameter | Detail | Comments |
|---|---|---|
| EU Baseline uptake (%) | 0% | No treatments currently licensed |
| Maximum potential uptake (%) | 100% | Can be applied across all slaughter facilities |
| Efficacy (%) | 40-80% | EFSA Scientific Opinion on control options (page 44, 45). 37-56% for lactic acid, 67-84% for TSP. |
| Cost (€ per 1000 birds) | €17-26 | Capital cost of dipping tank plus operational costs |
| Availability | Not available | Under development |
| Industry impact | Moderate | Additional investment across processing industry; small plants would be disproportionately disadvantaged. |
| Consumer impact | Moderate | This would increase retail price incrementally and there may be an issue of impact on product value. |

### 6.4.3 Freezing (2-3 weeks) (S3)

Freezing is already used in a few countries to treat carcasses from *Campylobacter*-colonised flocks (EFSA 2011) and it is therefore included in this study as a possible control option for the future. However, it is only a practical option in situations where the prevalence of contamination is low and even then it is likely that expanded cold-storage facilities would be required.

Whilst there is some evidence that the temporary on-line freezing of the surface of the carcass at the slaughterhouse ('crust-freezing') can reduce the number of *Campylobacter*, the control which is included in this study involves thorough freezing of all the carcass at a temperature of around -20ºC for 2-3 weeks. It is assumed that such freezing would take place off-site i.e. not at the slaughterhouse itself. Considerable practical and operational issues would be expected, even in Member States where the prevalence of contamination is low. These include additional transport costs to storage facilities and requirements for more frozen storage space and for controlled thawing of products that are not sold as frozen. Other financial implications include the lower value of frozen meat, compared to fresh and the greater risk of loss of market share to imports from third countries. Some of the additional costs estimated could be addressed if freezing was undertaken for just 2-3 days, rather than for 2-3 weeks but EFSA (2011) estimated a lower efficacy for such a regime.

Table 6.8 summarises the data located and the reliability of the data relating to the costs of the measure.

**Table 6.8 Summary analysis of control S3 (Freezing 2-3 weeks)**

| Parameter | Detail | Comments |
|---|---|---|
| EU Baseline uptake (%) | 0% | Freezing is applied in some countries in Northern Europe but not widely used. Assumed to be nil for fresh meat market. |
| Maximum potential uptake (%) | 100% | Can be applied across all slaughter facilities |
| Efficacy (%) | 90% | >90% EFSA 2011 |
| Cost (€ per 1000 birds) | €52-77 | Cost of contract freezing and transport |
| Availability | Moderate | Capacity would need to be expanded for contract freezing |
| Industry impact | High | Additional step and cost in the process but if contracted out, accessible to all. |
| Consumer impact | High | Demand for fresh meat is a distinct market. In the frozen market EU producers face greater competition from imported products |

### 6.4.4 Hot Water (S4)

Hot water and steam treatments have both been shown to reduce numbers of *Campylobacter* on the carcass surface, although the effects within the muscle are unlikely to be significant. Either treatment could be incorporated onto the processing line in the slaughterhouse; if steam were used, the volume of dirty water produced would be substantially less.

Hot water treatment is included as a possible control option, although it has been noted that the appearance of both chicken skin and any exposed muscle may be changed as a result of the process and this may affect the physical properties of the meat and visual presentation may be compromised, impacting on consumer acceptability. Within this study, it is assumed that hot water at a temperature of 80ºC would be applied to the carcasses for 20 seconds.

Table 6.9 summarises the data located and the reliability of the data relating to use of hot water as a control measure.

**Table 6.9 Summary analysis of control S4 (Hot Water)**

| Parameter | Detail | Comments |
|---|---|---|
| EU Baseline uptake (%) | 0% | Not currently applied in commercial context in EU |
| Maximum potential uptake (%) | 100% | Can be applied across all slaughter facilities |
| Efficacy (%) | 50-90% | Hot water immersion 1.25 log10 reduction (Corry et al., 2006) |
| Cost (€ per 1000 birds) | €40-61 | Based on estimate of per bird cost. |
| Availability | Moderate | Not currently used but could be implemented readily over a period of time. |
| Industry impact | High | Additional investment across processing industry; small plants would be disproportionately disadvantaged. |
| Consumer impact | High | Real concerns over acceptability as the process discolours the meat |

### 6.4.5 Irradiation (S5)

Irradiation, involving the use of gamma rays from isotopes such as cobalt 60 or x-rays, or electrons with appropriate energy spectra would be a very effective method for eliminating *Campylobacter* from chicken. Gamma rays and x-rays have greater penetration than electrons and are therefore reported to be more suited for the treatment of whole carcasses; electrons would be most suitable for use on smaller portions.

There would undoubtedly be issues with consumer acceptance of irradiation as a control method for chicken and these would need to be overcome if this was to be undertaken commercially. Nevertheless, this has been included as a possible control option for the future and it is assumed that irradiation would be undertaken at a separate off-site facility rather than at the slaughterhouse.

Table 6.10 summarises the results.

**Table 6.10 Summary analysis of control S5 (Irradiation)**

| Parameter | Detail | Comments |
|---|---|---|
| EU Baseline uptake (%) | 0% | Not licensed in EU |
| Maximum potential uptake (%) | 100% | Can be applied across all slaughter facilities |
| Efficacy (%) | 100% | Based on US data |
| Cost (€ per 1000 birds) | €82-122 | Includes costs for transport and irradiation (based on US data) |
| Availability | Not legal in EU at present | This technology is being applied in the US and would be available once it became legal in the EU. |
| Industry impact | High | Would be a contracted service with additional costs. |
| Consumer impact | High | Potential impact on market value due to consumer acceptance of irradiated meat. |

## 6.5 Product recall costs

Effective product recall procedures for *Campylobacter*-positive chicken products (carcasses, portions etc.) would potentially reduce the risk of Campylobacteriosis in humans and would serve as an incentive for all parts of the supply chain to implement and maintain the highest standards of control.

The basis for product recall would be the outcome of testing undertaken on samples of product at the end of all processing operations. An important issue would be to determine whether the pass / failure criteria would be based purely on the presence or absence of *Campylobacter* or would be subject to a risk assessment based on quantitative analysis, as carried out in Denmark. This decision would have important implications for the number of products tested, those considered to require recall, and the resulting costs and likely market disruption. The recent scientific evidence, and certainly the approach of the Danish authorities, is that the higher the level of contamination, then the greater the risk. For example the probability of acquiring campylobacteriosis from a product with 10-100 cfu *Campylobacter*/g would be 22 times lower than acquiring it from a product with 1,000 - 10,000 cfu *Campylobacter* /g. The Danish authorities have not set a specific pass/fail standard but carry out a risk assessment using a model that calculates risk from the profile of counts obtained from 12 samples (Maarten Nuata, personal communication).

Undertaking this sampling could be the responsibility of a food business operator, a competent authority or one that is shared by both. In Denmark the sampling and testing is the responsibility of the Danish competent authority.

Stakeholder opinion from other MS however is that effective product recall is not possible at present throughout the EU and for that reason associated costs are not included in the model. One reason stated by stakeholders is the time delay between testing and results being available, although as stated above Denmark has instigated a system of product recall. However Denmark has a low incidence of campylobacter contamination of carcasses compared with many other MS. (see Table 6.11).

**Table 6.11 Prevalence of Campylobacter-contaminated broiler carcasses, based on the combined results of the detection and enumeration method, by country and in the EU*, 2008 (EFSA, 2010a)s**

| Country | N (No of broiler batches) | % prevalence[3] | 95% CI[3] |
|---|---|---|---|
| Austria | 408 | 80.6 | 76.7 - 83.9 |
| Belgium | 380 | 52.7 | 44.8 - 60.5 |
| Bulgaria | 280 | 45.2 | 38.9 - 51.7 |
| Cyprus | 357 | 14.1 | 14.0 - 14.2 |
| Czech Republic | 422 | 68.6 | 65.5 - 71.5 |
| Denmark | 396 | 31.4 | 26.1 - 37.2 |
| Estonia | 102 | 4.9[1] | 2.1[1] - 11.2[1] |
| Finland | 369 | 5.5 | 5.4 - 5.5 |
| France | 422 | 88.7 | 84.3 - 91.9 |
| Germany | 432 | 60.8 | 53.6 - 67.7 |
| Hungary | 321 | 55.3 | 48.9 - 61.6 |
| Ireland | 394 | 98.3 | 98.0 - 98.5 |
| Italy | 393 | 49.6 | 39.5 - 59.7 |
| Latvia | 122 | 33.6 | 11.3 - 66.7 |
| Lithuania | 374 | 45.8 | 42.0 - 49.6 |
| Luxembourg[2] | 13 | 100 | 75.3[3] - 100[3] |
| Malta | 367 | 94.3 | 93.6 - 95.0 |
| Netherlands | 429 | 37.6 | 31.8 - 43.7 |
| Poland | 419 | 80.4 | 75.8 - 84.3 |
| Portugal | 421 | 70.2 | 58.7 - 79.7 |
| Romania | 357 | 64.2 | 51.9 - 75.0 |
| Slovakia | 422 | 79.1 | 68.8 - 86.7 |
| Slovenia | 413 | 77.8 | 70.7 - 83.6 |
| Spain | 389 | 92.6 | 89.8 - 94.7 |
| Sweden | 410 | 14.6 | 8.4 - 24.2 |
| United Kingdom | 401 | 86.3 | 79.6 - 91.0 |
| **EU (26 MS)*** | **9,213** | **75.8** | **73.2 - 78.3** |
| Norway | 396 | 5.1 | 3.1 - 8.3 |
| Switzerland | 408 | 71.7 | 63.8 - 78.5 |

1 As one slaughterhouse contributed to the entire survey, point estimate and 95% CI are based on logistic regression.

2 Exceptionally in Luxembourg no *Campylobacter* enumeration was executed in broiler carcass samples.

3 Prevalence estimates and CIs at national as well as at EU level were obtained taking into account correlation among within the same slaughterhouse. In addition, at EU level, prevalence estimates and CIs were weighted for the nationa slaughtered broilers during 2008.

* Greece did not participate in the baseline survey and two non-MSs, Norway and Switzerland, participated.

It would be impractical and not cost-effective to consider chemical decontamination of recalled batches as this would require removal and hygienic disposal of packaging , although freezing or irradiation may be options if sufficient freezer space were available and irradiation were a permitted treatment.  Under current production systems it would again be impractical to consider “positive release”, i.e. holding batched in a chiller until results are known, as there would be insufficient chiller space available.

If the issue of rapid product testing could be resolved, then suitable systems could be introduced whereby testing could be used in future both as a basis for further monitoring and quality control activity and as a basis for the withdrawal of product that failed to attain the threshold standard.

In terms of policy decisions on effective control of *Campylobacter* as modelled in this study, product recall costs should not be considered as an option for control but rather the avoidance of such costs is a benefit of effective control within the supply chain. While it may be possible to quantify recall costs on the basis of percentage product recalled at different levels of control, these should be considered outside the model, along with the social costs of control options.

High prevalence levels in other Member States could mean that large numbers of products would be subject to product recall and in addition to the issue of market disruption noted above; this may adversely affect public confidence in chicken meat and could result in reduced consumption levels.

# 7 Monitoring costs

## 7.1 Introduction

In the absence of EU-wide testing requirements for *Campylobacter* in poultry meat, two main testing points have been identified, as shown on the interventions map (Figure 5.1). These have been defined following consultations with industry and experts. A third testing point would also be appropriate later in the marketing chain (between the completion of processing and final sale), in order to check the level of *Campylobacter* in the final product. At present, the degree of commercial testing for *Campylobacter* is generally low at all parts of the supply chain. Some testing is undertaken on a voluntary basis and in accordance with customer requirements, but differences in approach can be seen in different Member States. Nevertheless, EFSA Journal 2011; 9(4):2105 recognises that microbiological criteria may be efficient tools to reduce risk because within-batch prevalence in contaminated batches is typically close to 100%. Hence there is less risk of recording false negative results due to the statistical limitations of sampling plans, but it should be accepted that testing is not 100% reliable.

The first test point (T1) would be undertaken on-farm shortly before live birds were sent for slaughter, thus providing an indication of the success of on-farm control strategies and an early warning of the *Campylobacter* status of flocks at the point of entry to the processing plant. In cases where flocks were thinned, it would be appropriate to re-test a flock just prior to final depopulation if the initial result (i.e. prior to thinning) was negative. Sampling would be undertaken by farm staff at stockman level and could be based on the collection of composite samples of 30 fresh faecal droppings from each house which would be submitted to a laboratory for analysis.

The second test point for *Campylobacter* (T2) would be undertaken at the processing plant. Since the freezing process is itself a control measure, testing would focus on product (whole carcasses and portions) that is marketed as fresh rather than frozen. Sampling would be undertaken immediately after processing by QC personnel at the plant. It is assumed that it would be based on the methodology set out in the EFSA baseline study (EFSA Journal 8(03) 1503), namely removing from one carcass the skin from a neck flap (if present), together with skin from one side of the carcass (breast skin) avoiding any fat, to make a test portion.

Responsibility for these two test points and the costs incurred would be borne by food business operators. It is assumed that any tests undertaken at subsequent points of the supply chain would be under the control of relevant competent authorities although in some cases, food business operators may also undertake sampling. Consistent with T2, this sampling would be limited to fresh (not frozen) products, with sampling as described for T2.

It is recognised that additional monitoring activities may also be needed, including farm audits following positive results for *Campylobacter* in chickens. It is likely that these audits would be undertaken by independent off-site staff and that the costs would generally be borne by the processor although they may also be reflected in the producer price. These activities have not been included as part of the model developed within this study.

## 7.2 Monitoring costs for food business operators

Food business operators would be responsible for the costs of T1 and T2 and these have been included within the model. Stakeholder consultation has indicated that T2 testing can only be used as a basis for remedial action in the future because products would be released for sale (and may have been consumed) by the time that test results have been received (see Section 6.5). Nevertheless it is likely that T2 will be important as part of an overall strategy where achievement of lower *Campylobacter* levels can be incentivised. So that the cost of T2 can be included in the model results its costs have been researched and entered in the model but T2 has no effect on efficacy of slaughterhouse measures.

Costs for T1 have been based on a testing price of around €25 per composite sample for each house plus courier and admin costs, a total of €30.  For a house of just under 25,000 birds, this is equivalent to a cost of €1.29 per 1000 birds.  The time taken to collect a sample is estimated at 15 minutes per house; this has not been included within the model since it is considered that sampling could be undertaken at the same time as other stockmanship duties.

At T2, an estimated cost of €20 (€10 - €30) per pooled sample would apply plus €30 for courier and administration per submission. The cost is estimated at €1.04 per 1000 birds throughput in the model.

This represents a cost at EU level of €6.9m for T1 and €4.6m for T2.

## 7.3 Monitoring costs for competent authorities

In accordance with Regulation (EC) No 2160/2003, on the control of *Salmonella* and other specified food-borne zoonotic agents, EU targets for poultry populations have already been set for the control of *Salmonella.* This has required competent authorities (CA) to draw up monitoring programmes (usually as part of their National Control Plan) for *Salmonella* in broiler flocks, with results of analyses to be known before scheduled slaughter.

Assuming that farm-level testing for *Campylobacter* is proposed to be similar in principle to *Salmonella* sampling then it will require separate samples as *Campylobacter* in birds is usually tested by testing of fresh faeces or caeca from slaughtered birds (salmonella is tested for in litter).  Also *Campylobacter* testing would be more useful later in a flock as it occurs more in older birds.  So unless *Salmonella* sampling can be delayed, adding *Campylobacter* sampling/testing would effectively double the sampling workload as a separate visit would be required.

Sampling of broilers for *Campylobacter* on the farm is more complicated than sampling for *Salmonella*.

- *Salmonella* is a robust organism that can persist and even multiply in the environment – Campylobacter will die off more quickly in the environment (and in samples) once shed from an animal
- *Salmonella* testing is carried out on boot swabs tests from litter.  Because it does not survive well outside of its host *Campylobacter* testing need to be carried out on freshly voided faeces or by testing gut or caecal contents from freshly slaughtered birds
- Sample transport and time between sampling and testing is more critical for *Campylobacter* than or *Salmonella* in order to get accurate results – it is recommended that samples are cooled and tested with 24 hours
- *Salmonella* infection usually occurs in the first 2-4 weeks of a flock and will persist, whereas *Campylobacter* infections usually appear late in the flock.  Therefore testing for *Campylobacter* should be left as late as possible to obtain an accurate picture of batch prevalence.  Testing for *Salmonella* is normally undertaken 3 weeks before scheduled slaughter but this would not be the optimum time for sampling for *Campylobacter*.

There are various options that could be adopted if *Campylobacter* sampling on farms were to be become mandatory.

**Option 1:** Separate visit by staff from competent authority to sample either freshly voided faeces* 5-8 days before slaughter.  Samples submitted to the laboratory for presence/absence test with results available before slaughter. The additional costs are estimated as slightly (1.2x) higher than current cost for CA sampling and testing for *Salmonella* as sampling would require more time to select fresh faeces than walking through the house with boot swabs.

(* taking caeca from slaughtered birds would take more time so would be more expensive)

**Option 2:** *Salmonella* sampling to be delayed to be taken at same time as *Campylobacter* sampling but present sampling for *Salmonella* (boot swabs) to be continued and separate samples taken for analysis of *Campylobacter* (i.e. fresh faeces). Extra costs would be extra sampling and analysis cost for *Campylobacter* plus time on farm for CA staff to give advice on measures to be taken to reduce future incidence of *Campylobacter*.

**Option 3:** *Salmonella* sampling to be delayed to be taken at same time as *Campylobacter* sampling and for tests for *Salmonella* to be carried out on same sample (i.e. fresh faeces) as that collected for *Campylobacter*. Extra costs would be extra analysis cost for *Campylobacter* plus time on farm for CA staff to give advice on measures to be taken to reduce future incidence of campylobacter.

<u>Costs</u>

The cost for Option 1 is set out below.

The UK estimates that the average total full economic costs per sampling visit for sampling and testing *Salmonella* on broiler farms is £230.17 (Defra, 2012); this equates to €293 at an exchange rate of £1 = €1.27. Given that most of the cost is staff time (generally veterinary auxiliaries) then the following table (taken from cost of veterinary involvement in meat plants) can be used to compare costs in certain MS. As stated above the extra costs for sampling and testing for *Campylobacter* at broiler farms are estimated as 1.2 times the cost of *Salmonella* sampling.

Table 7.1 below provides estimated costs for different member states. The mean cost stated for official auxiliaries and for official veterinarians is taken from cost provided for meat inspection tasks and are used for comparative purposes only.

At slaughter/processing, the relevant controls are Regulation EC 2073/2005 on the Microbiological Criteria for Foodstuffs. The sampling and testing here is the responsibility of the FBO not the CA. *Salmonella* is included (along with aerobic colony count and *E. coli* for meat preparations) but *Campylobacter* is not included. Again the responsibility for sampling and testing would lie with the FBO and not the CA. The CA is responsible for auditing the activities of FBOs, which include checking results of monitoring. If *Campylobacter* is added to the microbiological criteria regulation, it may add a very small additional time to each inspection/audit but in reality would not make much difference for CAs. It would clearly increase costs for FBOs.

## Table 7.1 Estimated costs of sampling and testing samples for Campylobacter on broiler farms

| MS | Mean cost for official auxiliary (€ per hour)* | Mean cost for official veterinarian (€ per hour)* | Estimated costs of sampling and testing samples for *Salmonella* on broiler farms (€ - cost per visit)[1] | Estimated costs of sampling and testing samples for *Campylobacter* on broiler farms based on estimated time required is 1.2 x time required for current *Salmonella* sampling(€ - cost per visit) |
|---|---|---|---|---|
| AT | 42 | 66 | 361.94 | 434.33 |
| BE | | 42.8 | 368.84[2] | 440.21 |
| BG | 1.2 | 1.9 | 10.3 | 12.36 |
| CY | 11 | 18.9 | 19.6 | 23.52 |
| CZ | 8.3 | 12.1 | 19.3 | 23.16 |
| DK | 32.8 | 54.3 | 282.66 | 339.19 |
| EE | 7 | 10 | 60.32 | 72.38 |
| FI | 21 | 49 | 180.97 | 217.16 |
| FR | 44.8 | 52.1 | 386.07 | 463.28 |
| DE | 20.6 | 42.4 | 177.52 | 141.02 |
| EL | | | | |
| HU | 2.6 | 8.3 | 22.40 | 26.88 |
| IE | 44 | 73 | 379.18 | 455.02 |
| IT | | 50 | 430.88[2] | 517.06 |
| LV | 5 | 6.5 | 43.09 | 51.71 |
| LT | 2.5 | 4 | 21.54 | 25.85 |
| LU | | 65 | 560.14[2] | 672.17 |
| MT | 13 | 20 | 112.03 | 134.44 |
| NL | 55 | 110 | 473.97 | 568.76 |
| PL | 5 | 12 | 43.09 | 51.71 |
| PT | 15.7 | 15.7 | 135.30 | 162.36 |
| RO | 1.8 | 3.5 | 15.51 | 18.61 |
| SK | 5.5 | 7.3 | 47.40 | 56.88 |
| SI | 5.8 | 14.1 | 49.98 | 59.98 |
| ES | 19 | 31 | 163.74 | 196.49 |
| SE | 66.1 | 97.3 | 569.63 | 683.56 |
| UK | 34 | 44 | 293.00 | 351.60 |

[1] based on comparison with €293 per visit in UK

[2] based on VO as no cost for Vet Aux

**Source: European Commission, DG SANCO*

# 8 Control strategies

## 8.1 Basis of control strategies

As discussed in Chapter 6, EFSA (2011)[14] suggested that a multi-layered intervention strategy would be optimal for *Campylobacter* control, with sequential intervention approaches targeting different points in production.

For each of the controls, the analysis at Chapter 6 sets out the baseline and potential uptake, estimated efficacy (range) and cost (range) and scores the control on its availability, impacts on industry and impacts on consumers. In this section, we look at the combinations of controls which might be used to deliver target reductions in *Campylobacter* in broilers of 50% and 90%. The basis for selection is cost effectiveness but we can override this on the basis of the other parameters.

The starting point is to consider how the range in efficacy and cost for each control plays out at an EU level in terms of overall reduction in *Campylobacter* achieved (allowing for uptake baseline and potential). This is set out in terms of percentage reduction in incidence and cost per DALY avoided for each control in Table 8.1 below. These values are model outputs. In view of the importance of the availability of the control and its potential impact on industry and consumers, these are presented alongside the effectiveness and costs estimates using traffic light coding.

**Table 8.1 Summary costs of *Campylobacter* controls**

| ID | Name | Reduction in incidence (%) | Cost per DALY avoided | | Availability | Industry impact | Consumer impact |
|---|---|---|---|---|---|---|---|
| | | | Lower estimate | Upper estimate | | | |
| F1 | Enhanced Biosecurity | 40-70% | €474 | €1,246 | | | |
| F2 | Early Slaughter | 10-50% | €9,526 | €35,724 | | | |
| F3 | No Thinning | 10-25% | €1,914 | €7,180 | | | |
| F4 | Vaccination | 50-90% | €2,653 | €7,162 | | | |
| F5 | Bacteriocins | 50-90% | €2,714 | €7,330 | | | |
| S1 | Best practice hygiene | 20-30% | €1,487 | €3,347 | | | |
| S2 | Chemical Decontamination | 40-80% | €1,078 | €3,235 | | | |
| S3 | Freezing (2-3 weeks) | 90-95% | €2,710 | €4,291 | | | |
| S4 | Hot Water | 50-90% | €2,248 | €6,068 | | | |
| S5 | UV Irradiation | 100% | €2,536 | €3,804 | | | |

The wide range in scope of individual controls to secure substantive reductions in *Campylobacter* incidence and the wide range in costs of doing so indicates that there is a need to combine controls as part of a strategy in order to meet the target reductions. This is detailed in Section 8.2 below in terms of achieving the 50% and 90% reduction targets for both the lower band and upper band estimates of efficacy. These are referred to as pessimistic and optimistic scenarios, respectively.

A central estimate of (annualised) cost is used to generate cost estimates for the controls, assuming a mid-point efficacy. Alongside this, benefits in terms of cost of illness saved have been monetised based on work by Mangen et al (2007), so that tangible costs and benefits can be quantified for each control at EU level. These are presented for all ten controls in

[14] Scientific Opinion on *Campylobacter* in broiler meat production: control options and performance objectives and / or targets at different stages of the food chain

Table 8.2 along with the net cost of intervention for each control (cost of control less cost of illness saved) per DALY averted.

**Table 8.2 Summary costs of *Campylobacter* controls**

| ID | Name | Reduction in incidence (%) | EU cost of control € million | EU cost of illness saved € million | EU Net cost per DALY averted € |
|---|---|---|---|---|---|
| F1 | Enhanced Biosecurity | 44% | 36.7 | 333.8 | -6,102 |
| F2 | Early Slaughter | 15% | 288.1 | 116.1 | 10,154 |
| F3 | No Thinning | 12% | 43.6 | 87.4 | -3,438 |
| F4 | Vaccination | 64% | 297.7 | 478.8 | -2,594 |
| F5 | Bacteriocins | 64% | 297.7 | 478.8 | -2,594 |
| S1 | Best practice hygiene | 23% | 54.0 | 166.1 | -4,626 |
| S2 | Chemical Decontamination | 60% | 116.1 | 442.9 | -5,060 |
| S3 | Freezing (2-3 weeks) | 93% | 346.5 | 682.9 | -3,377 |
| S4 | Hot Water | 70% | 272.2 | 516.8 | -3,245 |
| S5 | UV Irradiation | 100% | 341.3 | 738.2 | -3,687 |

The data highlights the broad range in efficacy and cost of the controls and the consequent range in benefits. Control F2 is notable as being the only control where the cost of implementation outweighs the benefits in terms of cost of illness saved; this relates to a combination of low efficacy and high cost.

## 8.2 Analysis of control strategies

This data on individual controls contributes to the analysis of potential strategies but these must account for not only cost effectiveness but wider issues such as availability of the control and impacts on industry or consumers.

### 8.2.1 Scenario 1: Reducing prevalence in poultry by 50%

This sub-section considers strategies that deliver a 50% reduction in attributable human campylobacteriosis assuming all other conditions remain unchanged.

Under the pessimistic scenario (using lower range values for efficacy) and a target reduction of 50% in *Campylobacter* challenge, the following strategies were selected by the model. This is described as Control Strategy 1a (CS1a).

**Table 8.3 Summary costs of *Campylobacter* control strategy CS1a**

| Control name and (efficacy %) | Reduction in EU incidence (%) | Annual cost per DALY avoided | | Availability | Industry impact | Consumer impact |
|---|---|---|---|---|---|---|
| | | Lower estimate | Upper estimate | | | |
| F1 Enhanced Biosecurity (40%) | 59% | €1412 | €2118 | | | |
| T1 On-farm Testing | | | | | | |
| S2 Chemical Decontamination (40%) | | | | | | |
| T2 Post slaughter Testing | | | | | | |

This strategy is attractive insofar as it meets the target reduction in *Campylobacter* at a moderate cost of €1412-2118 per DALY avoided (including testing), and an estimated total **cost of implementing CS1a is €91-136 million per annum** across the EU to industry. While the Enhanced Biosecurity measure is fully available at present and has low impact on industry and no direct impact on consumers (control costs would have to be passed on), the Chemical Decontamination measure is not yet available (only one substance has been assessed as satisfactory by EFSA) and may have major consumer impacts.

A key challenge is to ensure widespread compliance with a requirement to employ enhanced biosecurity on farm which relies on investment in facilities and time and will incur operational costs; this may be difficult to audit. This approach therefore needs to align the commercial self-interest of the supply chain with the strategy to ensure it delivers low levels of *Campylobacter* prevalence at the point of sale. In other words, testing of poultry meat as it leaves the processing plant is key and a system of incentives and/or penalties would need to be applied so that processors managed their own supply chain, including biosecurity at supplying production units, and internal hygiene processes to deliver results. Inspection programmes would need to be in place to ensure testing procedures were robust and being adhered to; this could be on a sample basis, as is the case for many regulatory controls. Where possible, this might be added to existing inspection protocols with limited additional public and private cost. A carefully planned communications effort that raised consumers' awareness of *Campylobacter* as an issue should also encourage more extensive use of private performance standards within the supply chain.

When the upper range efficacy values are used, only the farm biosecurity control F1 is selected. Assuming, testing points T1 and T2 were essential component elements to drive implementation of such a strategy, the cost per DALY avoided reduces to €581-872. This is described as Control Strategy 1b (CS1b) and the estimated **annual cost of implementing CS1b is €36-54 million** to industry at EU level.

**Table 8.4 Summary costs of *Campylobacter* control strategy CS1b**

| Control name and (efficacy %) | Reduction in EU incidence (%) | Annual cost per DALY avoided | | Availability | Industry impact | Consumer impact |
|---|---|---|---|---|---|---|
| | | Lower estimate | Upper estimate | | | |
| F1 Enhanced Biosecurity (70%) | | | | | | |
| T1 On-farm Testing | | | | | | |
| T2 Post slaughter Testing | 56% | €581 | €872 | | | |

Given the risks associated with effective implementation of F1 and the potential consumer acceptability issues associated to S2, the model was re-run with these controls excluded to see what other control or combination of controls might be used to deliver the 50% target reduction in *Campylobacter* prevalence. For this analysis, the remaining controls were assumed to achieve their mid-point efficacy value. The result is shown below and represents control strategy 1c (CS1c).

**Table 8.5 Summary costs of *Campylobacter* control strategy CS1c**

| Control name and (efficacy %) | Reduction in EU incidence (%) | Annual cost per DALY avoided | | Availability | Industry impact | Consumer impact |
|---|---|---|---|---|---|---|
| | | Lower estimate | Upper estimate | | | |
| T1 On-farm Testing | | | | | | |
| S4 Hot Water (70%) | | | | | | |
| T2 Post slaughter Testing | 70% | €1997 | €2996 | | | |

While this strategy clearly represents a greater degree of potential reduction in *Campylobacter* prevalence than CS1a and CS1b, the cost is higher; the estimated **annual cost of implementing CS1c is €151-226 million** to industry. Additionally there may be substantive impacts on the acceptability of hot water treated meat to consumers.

Bearing in mind the potential significance of consumer impacts of CS1c, for the final strategy option for reducing prevalence in poultry by 50% all post slaughter controls were switched off, leaving only farm level controls (and Best Practice Hygiene). The result is shown below and represents control strategy 1d (CS1d).

**Table 8.6 Summary costs of *Campylobacter* control strategy CS1d**

| Control name and (efficacy %) | Reduction in EU incidence (%) | Annual cost per DALY avoided | | Availability | Industry impact | Consumer impact |
|---|---|---|---|---|---|---|
| | | Lower estimate | Upper estimate | | | |
| F1 Enhanced Biosecurity (55%) | 57% | €866 | €1298 | | | |
| T1 On-farm Testing | | | | | | |
| S1 Best Practice Hygiene (25%) | | | | | | |
| T2 Post slaughter Testing | | | | | | |

This is a moderately expensive option based on current costing of these controls (estimated at €866-1298 per DALY avoided) with an **annual cost of implementing CS1d is €54-80 million** to industry of implementing CS1d. Additionally, the CS1d strategy has no direct impacts on consumers. The strategy relies on achieving the mid-point efficacy for F1 and S1.

Across the Scenario 1 strategies, the **EU level cost of implementation ranges from €36-226 million per annum** with the 62-75 thousand DALYs averted, depending on the level of control achieved (50-70%).

### 8.2.2 Scenario 2: Reducing prevalence in poultry by 90%

It is anticipated that the cost associated with achieving 90% reduction in *Campylobacter* prevalence in poultry will be substantially more expense that for the 50% target.

As with scenario 1, the model was first run with lower range values for control efficacy for all controls. In this circumstance, the model selects Enhanced Biosecurity (F1) and Freezing (S3). S3 comes in because of its relatively high efficacy value. This is Control Strategy 2a (CS2a). The reduction in *Campylobacter* is calculated at 93% and the cost is €1589-2383 per DALY avoided or an **annual cost of implementing CS2a is €160-239 million** per year across the EU.

**Table 8.7 Summary costs of *Campylobacter* control strategy CS2a**

| Control name and (efficacy %) | Reduction in EU incidence (%) | Annual cost per DALY avoided | | Availability | Industry impact | Consumer impact |
|---|---|---|---|---|---|---|
| | | Lower estimate | Upper estimate | | | |
| F1 Enhanced Biosecurity (40%) | 93% | €1589 | €2383 | | | |
| T1 On-farm Testing | | | | | | |
| S3 Freezing (2-3 weeks) (90%) | | | | | | |
| T2 Post slaughter Testing | | | | | | |

Freezing would not only add considerable direct cost to the supply chain but effectively stocks would need to be held for 2-3 weeks with considerable additional financial cost. It might be worth considering 2-3 day freezing both to limit investment in new capacity required, and costs and practicality to the supply chain. There are also potentially significant consumer impacts in terms of supply of fresh chicken and the risk of drawing in imports, with subsequent economic impacts for the EU industry.

To explore alternatives, the efficacy of Enhanced Biosecurity (F1) was held at the lower value but higher range values selected for other controls. In this case S2 (Chemical Decontamination) displaces Freezing (F3) and both F1 and S1 are included.

**Table 8.8 Summary costs of *Campylobacter* control strategy CS2b**

| Control name and (efficacy %) | Reduction in EU incidence (%) | Annual cost per DALY avoided | | Availability | Industry impact | Consumer impact |
|---|---|---|---|---|---|---|
| | | Lower estimate | Upper estimate | | | |
| F1 Enhanced Biosecurity (40%) | 90% | €1146 | €1720 | | | |
| T1 On-farm Testing | | | | | | |
| S1 Best Practice Hygiene (30%) | | | | | | |
| S2 Chemical Decontamination (80%) | | | | | | |
| T2 Post slaughter Testing | | | | | | |

This is Control Strategy 2b (CS2b). The level of control achieved is 90% and the DALY avoided cost is €1146-1720, with an **annual cost of implementing CS2b €111-167 million** per year.

CS2a and CS2b both employ post slaughter controls to meet the target reduction of 90% ahead of farm level options. Given the consumer impacts from both S3 (Freezing) and S2 (Chemical Decontamination), all post-slaughter controls were switched off in order to force selection of farm level controls with potential consumer impacts. F1 and S1 were set at the mid-point of the efficacy range while all other farm-level controls were set at the upper limit in order to deliver 90% target. This is Control Strategy 2c (CS2c).

**Table 8.9 Summary costs of *Campylobacter* control strategy CS2c**

| Control name and (efficacy %) | Reduction in EU incidence (%) | Annual cost per DALY avoided | | Availability | Industry impact | Consumer impact |
|---|---|---|---|---|---|---|
| | | Lower estimate | Upper estimate | | | |
| F1 Enhanced Biosecurity (55%) | 92% | €2739 | €4108 | | | |
| F4 Vaccination (90%) OR<br>F5 Bacteriocins (90%) | | | | | | |
| T1 On-farm Testing | | | | | | |
| S1 Best Practice Hygiene (25%) | | | | | | |
| T2 Post slaughter Testing | | | | | | |

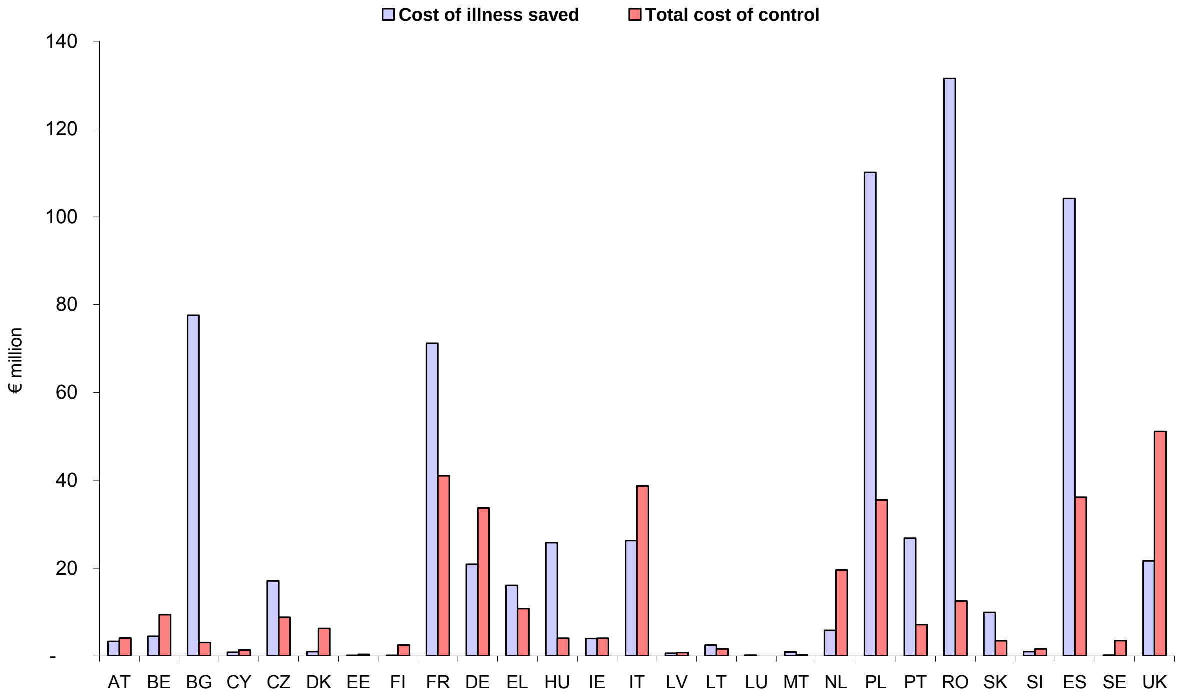
If this strategy can be realised, notably uptake of F1 and S1, then while it is more expensive to implement than CS2a or CS2b, at an **annual cost of implementing CS2c is €273-410 million**, it would have lesser impacts on industry and consumers. With technological advances it may be that F4 or F5 can be more cost effective when implemented widely (e.g. due to scale economies on vaccine/bacteriocin production).

Across the Scenario 2 strategies, the **EU level cost of implementation ranges from €111-410 million per annum** with the 97-100 thousand DALYs averted, depending on the level of control achieved (90-93%).

## 8.3 Distribution of costs and benefits

The distribution of costs across MS largely reflects the relative populations of indoor broilers across the EU. In terms of the distribution of benefits (in cost of illness saved), these reflect the extent of human campylobacteriosis. The large range in absolute scale between MS and the lack of coincidence of distribution of costs and benefits is illustrated in Figure 8.10 for CS2c and discussed further in Chapter 10. While the detailed distribution varies across strategies, these issues are common to all.

**Figure 8.1 Distribution of costs and benefits to achieve 90% reduction in *Campylobacter* by CS2c**




It is also notable that the non-monetised benefits in terms of DALYs averted under CS2c varies considerably across MS, in proportion to the cost of illness saved. The range is from less than 100 DALYs (EE, FI, LV, LU and SE) to over 10,000 DALYs (BG, FR, PL, RO and ES). Consequently in terms of cost utility, the economic and social case for intervention is disparate across MS.

# 9 Economic and social impacts

The control of *Campylobacter* has three main impacts on economic growth:

(i) Additional costs: Regulating to mandate control of *Campylobacter* in poultry will invariably add to the costs of the broiler meat production and processing sector and may result in a reduction in the scale of production or its economic performance due to substitution by imports from third countries or a fall in the consumption of poultry meat. In either case, there would be an associated loss of economic output and jobs on farm and upstream.

(ii) Improved health: Through reducing the prevalence of *Campylobacter* in poultry (and the wider environment), there will be a positive impact on economic growth through reduced absence from work and lower health costs associated with treating campylobacteriosis.

(iii) Industry restructuring: The baseline prevalence of *Campylobacter* in poultry and human campylobacteriosis varies significantly across Europe as does the cost of implementing the controls considered in this study. The application of mandatory controls across Europe will create a shift in the relative competitiveness of MS in the production and processing of poultry meat. This is anticipated to lead to a restructuring of the sector across the EU with both winners and losers. This would have differential impacts of economic growth in different MS.

These issues are discussed in more detail in this chapter.

## 9.1 Increased costs for the broiler sector

The value of chicken meat production in the EU is approximately Euro 18 billion per year and growing. The costs of the Control Strategies discussed in Section 9 of this report vary from Euro 8 million per year to Euro 389 million per year; this represents 0.1% and 2.2% of the value of poultry meat production in the EU respectively. However it is dangerous to assume that a small increase in production costs will have little effect on the competitiveness of EU chicken production.

Firstly, it is important to recognise that the cost of *Campylobacter* control must be viewed in the context of existing regulatory costs (animal health and welfare, labour costs, environmental costs etc.) met by the broiler production and processing sector. This is difficult to quantify because regulatory costs are not always well documented. Further, the relationship between increased costs and the loss of production may not be linear. A "tipping point" may be reached where a small increase in production costs results in a major loss of production to increased imports.

*Campylobacter* control in EU poultry meat production would have some positive effects for EU poultry production. Reduced levels of human campylobacteriosis and the associated improved reputation of EU poultry meat supplies should help the volume of home consumption and exports, although the impact may be limited due to the market failures that surround improved food quality which are not readily discernible to the final consumer. There may be competitiveness benefits in the short term if controls on *Campylobacter* were required for imports of poultry meat into the EU, but major exporters to the EU such as Thailand and Brazil would probably be able to apply these controls at a lower cost than the EU, because, for example, of lower labour costs.

## 9.2 Reduced illness

A potential reduction of 105,000 DALYs each year would be associated with 100% reduction in *Campylobacter* in poultry meat produced in the EU and is a measure of the positive impact available. DALYs are a metric for wellbeing and relate to productive members of the EU's labour force[15] across the whole range of industries. Absences from work caused by campylobacteriosis can cause considerable disruption to the work force. If these productive days were not lost there would be a beneficial impact of economic output although the benefit is hard to quantify. In the case of those members of the population not employed, the benefits are still real but even harder to quantify.

## 9.3 Distribution of costs and benefits by Member States

There are three key parameters which affect the distribution of costs and benefits by MS, namely:

- the scale of the poultry production sector;
- the prevalence of *Campylobacter* in poultry meat; and
- the incidence of *Campylobacter* related human illness.

These do not have a common coincidence across MS and this can lead to very disparate levels of costs per DALY saved.

The model created for this study allows policymakers to look at differences in the costs of control and the benefits in different MS. This is illustrated for one of the control strategies, CS1d, in Table 9.10. In this control strategy a reduction of 57% in incidence is achieved (target of 50% control set) with the controls applied being F1 (Enhanced Biosecurity) and S1 (Best Practice Hygiene) in combination with tests T1 on farm and T2. The total central cost is estimated at Euro 67 million per year and the average cost per DALY saved across all MS is Euro 1,082.

Care should be taken when interpreting this data, not only on the basis of high levels of uncertainty over key parameters such as baseline incidence, control efficacy and costs but also due to a degree of under-reporting of campylobacteriosis in all MS.

Cost per DALY avoided is a good measure of the impact on economic growth because it brings together the costs and benefits and provides a basis for comparing strategies. In order to consider absolute cost: benefit of the strategies, it is necessary to monetise the benefits. The benefits relate to both a reduced burden of disease and reduced costs of illness. In our model we have used an estimated value for cost of illness from the literature to calculate the net cost of intervention, that is, cost-of-illness avoided less cost of intervention, per DALY averted. This is consistent with the CAMRA approach which estimated a cost-utility ratio (CUR) for interventions, expressed in net costs per averted DALY. Mangen et al did not attempt to monetise the DALY due to the difficulties in attributing a value and the same approach has been taken by the authors of this study.

The analysis of net cost of intervention per DALY highlights the fact that a number of countries (notably in Scandinavia) have a positive cost-utility ratio, that is, intervention costs exceed cost-of-illness (see Table 9.10). This largely reflects the low level of campylobacteriosis in the human population (4% incidence in Finland, 13% in Sweden and 19% in Denmark); in these countries, this limits the extent of benefits achieved for an industry-wide application of controls, which results in very high net costs of *Campylobacter* control of more than Euro 10,000 per human DALY averted. Although there is an adjustment in the baseline or maximum uptake for some measures (F1, F2, F3) for these countries, controls are applied across the whole sector in order to address a very small incidence of campylobacteriosis. In practice, there would need to be tailored implementation with perhaps derogation for MS where the prevalence levels are already low.

It should be borne in mind that even though some interventions do have a positive cost-utility ratio, they are still highly cost-effective according to WHO criteria (WHO, 2003) as the costs per DALY are well below GDP, even in Scandinavian countries. So according to accepted criteria in health economics, the interventions would be supported.

[15] The disability-adjusted life year is a metric that expresses only the economic value of a given life year of a given individual to members of society other than that individual; it does not capture wider social value.

In contrast, MS where the number of human cases of campylobacteriosis is high, such as Poland, Romania and Spain (1.4-1.7 million cases per year), the number of DALYs saved is high (9-12 thousand) and the control cost per DALY saved is low at less than Euro 1000 per DALY. The case here for intervention is much stronger. However, differential implementation of controls will cause shifts in the competitiveness of individual MS and could lead to restructuring of production and/or processing across the EU. Ultimately this will impact on economic growth.

**Table 9.1 The Cost of Control by Member States for Control Strategy 1D**

| MS | Incidence | | Human Cases | | DALYs saved | Total control cost, million euro | Cost of illness saved, million euro | Cost: Utility Ratio (CUR) |
|---|---|---|---|---|---|---|---|---|
| | Baseline % | Post control % | Baseline | Post control | | | | |
| Austria | 48 | 20 | 43,964 | 36,218 | 301 | 1.1 | 2.1 | -3,072 |
| Belgium | 31 | 13 | 59,880 | 49,330 | 410 | 1.9 | 2.8 | -2,279 |
| Bulgaria | 30 | 12 | 1,030,036 | 848,550 | 7,058 | 0.4 | 48.4 | -6,807 |
| Cyprus | 31 | 13 | 11,347 | 9,348 | 78 | 0.3 | 0.5 | -2,448 |
| Czech | 61 | 25 | 227,360 | 187,301 | 1,558 | 1.2 | 10.7 | -6,115 |
| Denmark | 19 | 11 | 13,721 | 12,005 | 67 | 1.3 | 0.5 | 12,151 |
| Estonia | 2 | 1 | 2,185 | 1,912 | 11 | 0.0 | 0.1 | -4,982 |
| Finland | 4 | 2 | 1,586 | 1,388 | 8 | 0.3 | 0.1 | 29,283 |
| France | 76 | 38 | 1,081,207 | 918,357 | 6,333 | 11.4 | 43.4 | -5,052 |
| Germany | 49 | 20 | 277,569 | 228,663 | 1,902 | 7.5 | 13.0 | -2,890 |
| Greece | 65 | 27 | 213,360 | 175,767 | 1,462 | 1.9 | 10.0 | -5,548 |
| Hungary | 50 | 21 | 342,725 | 282,339 | 2,348 | 0.6 | 16.1 | -6,597 |
| Ireland | 83 | 34 | 52,833 | 43,524 | 362 | 0.9 | 2.5 | -4,254 |
| Italy | 63 | 26 | 349,136 | 287,620 | 2,392 | 8.3 | 16.4 | -3,388 |
| Latvia | 41 | 17 | 8,443 | 6,955 | 58 | 0.1 | 0.4 | -5,449 |
| Lithuania | 42 | 17 | 32,999 | 27,185 | 226 | 0.2 | 1.6 | -6,118 |
| Luxembourg | 100 | 41 | 2,122 | 1,748 | 15 | 0.0 | 0.1 | -6,756 |
| Malta | 97 | 40 | 11,778 | 9,703 | 81 | 0.1 | 0.6 | -6,235 |
| Netherlands | 24 | 14 | 81,340 | 71,169 | 396 | 2.6 | 2.7 | -279 |
| Poland | 79 | 33 | 1,462,631 | 1,204,925 | 10,022 | 5.6 | 68.7 | -6,302 |
| Portugal | 82 | 34 | 355,915 | 293,205 | 2,439 | 1.2 | 16.7 | -6,346 |
| Romania | 77 | 32 | 1,747,108 | 1,439,278 | 11,971 | 1.6 | 82.1 | -6,720 |
| Slovakia | 74 | 30 | 131,537 | 108,361 | 901 | 0.5 | 6.2 | -6,321 |
| Slovenia | 78 | 32 | 13,038 | 10,741 | 89 | 0.3 | 0.6 | -3,652 |
| Spain | 88 | 36 | 1,383,619 | 1,139,834 | 9,481 | 6.9 | 65.0 | -6,132 |
| Sweden | 13 | 8 | 2,749 | 2,405 | 13 | 0.6 | 0.1 | 35,462 |
| UK | 75 | 31 | 287,654 | 236,971 | 1,971 | 10.3 | 13.5 | -1,644 |
| **Total EU** | | | **9,227,842** | **7,634,802** | **61,952** | **67.0** | **424.8** | **-5,775** |

A further group of countries (including NL and UK) have a net cost of intervention (positive Cost Utility Ratio) in some of the other strategies, for example, in CS1a and CS2a. In these cases the issue is a low prevalence of campylobacteriosis relative to the poultry population are combined with high costs of implementing controls, outweighing the benefits at MS level.

This analysis also raises the issue of targeted implementation of controls within MS. This provides industry with a commercial incentive to implement the least cost biosecurity and best practice controls voluntarily in order to avoid higher cost mandated controls. This would minimise regulatory intervention and minimise private and public costs but there are considerable challenges in implementing such an approach. Key to this would be mandatory testing and reporting; the commercial pressures to avoid controls would require that this was monitored by public officials.

## 9.4 Impacts on broiler meat imports

One mechanism by which a new *Campylobacter* control strategy could impact on the EU's broiler supply chain is through changes in the relative competitiveness of EU products as compared to extra-EU imports, e.g. through imposition of additional costs that resulted in higher prices. As noted above, the scale of the cost increment does not necessarily have to be very high to have an effect on achieved margins or on the relative competitiveness in competitive markets.

However, as noted in section 3.4.1, extra-EU chicken meat trade mostly consist of frozen products. In 2011, only 0.5% of the extra-EU imports were fresh or chilled chicken products while 99.5% were frozen. The implication of this is that a control measure which results in EU producers being obliged to put proportionately more of their output into the domestic EU frozen chicken product markets (whether for food retail or food service) is likely to have a higher impact than one which is limited to the fresh market in which EU producers are more insulated from international competition.

In that context, trade-mediated impacts on the EU sector would not be expected to be particularly significant under control strategies which do not include freezing as one of the selected control measures. By contrast, strategies which select freezing as a means of achieving the reduction target would push a larger share of EU broiler output into markets where they are in direct competition with imports. This option would thus have a greater potential to lead directly to a change in market share between EU producers and those in third countries whereas other the control strategies are more likely to change the competitive dynamics within the EU. In those other options trade-mediated impacts would be more likely to occur through indirect mechanisms, e.g. through changes in relative prices.

## 9.5 Other impacts

This study is required to consider other potential impacts, such as losses of sales due to loss of consumer confidence.

There are certain challenges in considering the potential of the control strategy on consumer confidence because there is not necessarily a stable relationship between consumer 'confidence' and the evidence available about the extant risks posed by a given product. As of 2012, many of the chicken products sold to consumers in the EU are contaminated with *Campylobacter*. Evidence on and scale and distribution of the problem is in the public domain yet there is little evidence that the current situation is leading to loss of sales.

If safely prepared and cooked these products should not pose a material risk to human health, but the contingent risk of illness in the remains while food hygiene standards are imperfect. The question therefore arises of which of two following scenarios is more likely:

- The current situation is an 'unstable' position. In this business-as-usual scenario there is a substantive risk of the issue 'breaking out' into a matter of wider public concern, triggering a reduction in confidence in EU broiler sector and associated loss of sales (perhaps triggered by a significant increase in incidence of campylobacteriosis);

- The current situation is essentially 'stable' and provides a helpful context for efforts by industry and regulators to progressively reduce the presence of *Campylobacter* in the production sector and supply chain without major disruption to the sector. Introducing measures, such as product recalls, which appeared to place *Campylobacter* in a different category of official concern, themselves risk triggering a loss of confidence in the market and exacerbating the disruptive negative impacts of the strategy.

Despite its prevalence, the 'visibility' of *Campylobacter* in public consciousness is not particularly high. In perceptions and questions it may be subsumed within a general concern about food safety / food poisoning, both in the consumer's mind and also in the way issues are presented by food safety authorities. To take one example the biannual consumer attitudes tracking survey commissioned by the UK Food Standards Agency[16], mentions *Salmonella* and *E. Coli* but not *Campylobacter*.

The above analysis suggests that the key issue for the control strategy is actually how best to align the power of informed consumer choice to the objectives of the control strategy, without triggering the kind of loss of confidence or 'panic' that could discourage the industry from proceeding and/or undermine progress during the implementation phase. It suggests that careful thought should be given to the design and implementation of a communication strategy alongside the definition of the core control strategy.

[16] Food Standards Agency. Biannual Public Attitudes Tracker. November 2011 results. http://www.food.gov.uk/multimedia/pdfs/biannualpublicattitudestrack.pdf

# 10 Conclusions

This project has developed a model that enables the estimation of costs for application of a variety of *Campylobacter* control measures in Europe. This report provides an overview of the results that emerge when the available data are applied to that model. This is a strategic appraisal that lays the foundation for more detailed work on preferred measures in the future.

Core conclusions are:

- Improved farm biosecurity (F1) and best practice hygiene at the slaughter plant (S1) are among the most cost-effective measures, are currently available and can be implemented widely. The costs of implementation across the EU are estimated at €37m and €54m respectively with benefits in terms of cost of illness avoided, valued at €334m and €166m. Critically, there are no issues of market adjustment or consumer choice. Implementation would need to be driven by the supply chain itself together with a regulatory inspection programme to evidence both action and results. Testing at T1 and T2 are essential components of this approach.
- F1 and S1 can deliver the 50% reduction target but only in combination and at higher levels of efficacy. Where there is insufficient commitment from industry to implement F1 and S1 fully, lower efficacy values should be assumed and this would bring other controls into play. The most cost-effective of these options is Chemical Decontamination (S2) (cost €113m and benefits €441m) and Hot Water treatment (S4) (cost €188m and benefits €517m), both post slaughter. These options would deliver higher levels of *Campylobacter* control than F1 and S1 but are more expensive to implement and would impact on consumer choice and subsequently on markets and producers.
- The farm-level control options selected by the model when post-slaughter options are not available are vaccination (F4) and bacteriocins (F5). While these controls would avoid many of the consumer impacts, they are currently very expensive to implement (both at a cost of €298m) but would deliver higher levels of *Campylobacter* control (benefits of €479m) and would ultimately impact on consumers through prices. When forced in as a control, as with CS2c, the estimated implementation cost is invariably high at €273-410 million. With technological advances these options may become competitive and may be preferred in terms of limited disruption to production systems and market supply (which will entail substantive social costs which are not captured in the model).
- Early Slaughter (F2) and No Thinning (F3) are not selected in any of the strategies due to a combination of low efficacy relative to cost of implementation. They would also cause major disruption to markets if implemented across Europe. However, it is clear that tactical use by individual producers as part of a farm-level strategy may be helpful in controlling *Campylobacter*. These options are most appropriate as optional controls for industry use rather than as a basis for legislation.
- Freezing (S3) and UV Irradiation (S5) are not generally selected due to high cost but when a high level of *Campylobacter* control is required and lower efficacy ranges are assumed for other controls, as with the 90% target in scenario 2, they can come into play. For example, in CS2a, freezing is included alongside F1 but the annual cost is estimated at €160-239 million.
- Targeted use of controls is important where the prevalence of *Campylobacter* is low, both across the EU and within MS. The net cost per DALY can be very high where controls are applied across the whole sector to secure relatively modest reductions in DALYs. This is most common where the baseline incidence of human campylobacteriosis is low in Scandinavian countries but also applies to the Netherlands and the UK in some cases due to the large poultry populations, relative to humans.
- Scheduled slaughter, as identified by EFSA is a key component of a strategy to limit generic use of controls where this is not necessary. By identifying flocks positive for *Campylobacter* before they are slaughtered and applying controls selectively to these flocks at the processing stage, impact and cost of controls such as freezing, heat

treatment or chemical decontamination can be minimised. This approach is already used in Denmark. However the efficacy of testing and the high probability of late positive flocks will have an impact.

- The first test point (T1) would be undertaken on-farm shortly before live birds were sent for slaughter. Assuming that farm-level testing for *Campylobacter* is proposed to be similar in principle to *Salmonella,* the extra costs for sampling and testing for *Campylobacter* at broiler farms are estimated at 1.2 times the cost of *Salmonella* sampling but there may be opportunities to make savings by harmonising the procedures for sampling for both.
- T2 would provide the basis for product recall. While recall is operational in Denmark, stakeholder opinion from other MS is that effective product recall is not possible at present throughout the EU due to much higher levels of *Campylobacter* presence. As associated costs are not available, recall has not been included in the model; this could be added at a future date if an EU control programme was in place and relevant data available.
- Monitoring costs incurred for *Campylobacter* control would be borne by food business operators and competent authorities. Costs for T1 have been estimated at €1.29 per 1000 birds while costs for T2 are estimated at €1.04 per 1000 birds in the model. This represents a cost at EU level of €6.9m for T1 and €4.6m for T2.

In summary, selection of controls is very sensitive to the assumptions on baseline adoption and potential uptake and cost of implementation. The values used in the model are very broadly based – mainly at EU level – and do not truly reflect MS conditions. As such the analysis of differential impact should only be used as an approximate guide in the absence of full MS level data on uptake and costs.

The main impacts of Campylobacter control on economic growth relate to the imposition of additional costs on industry and the subsequent changes in the competitive position of the EU and third countries and between MS. On the other hand there are potentially positive economic impacts from reduced human illness on the economies and from enhanced consumer confidence in fresh poultry meat. Given the current low profile of *Campylobacter* with consumers, a key issue for the control strategy is to design and implement a communication strategy alongside the definition of the core control strategy.

# ANNEXES

# Annex 1 Terms of reference

## A1.1 Title of the assignment

Analysis of the costs and benefits of setting certain control measures for reduction of *Campylobacter* in broiler meat at different stages of the food chain.

## A1.2 Context of the assignment

### A1.2.1 Issue at stake (*Scoping Paper point 1*) – description of the problem definition (causes), its nature, magnitude

The purpose of the contract is to provide the Commission with an analysis of the costs and benefits of setting certain control measures for reduction of *Campylobacter* in broiler meat at different stages of the food chain.

A total of 198,252 cases of campylobacteriosis were reported in the EU in 2009, continuing as in the previous four years to be the most commonly reported gastrointestinal bacterial pathogen in humans in the EU. *Campylobacter* can cause diarrhoea and fever, in foodstuffs it was mostly found in raw poultry meat.

In accordance with Regulation (EC) No 2160/2003 on the control of *Salmonella* and other specified food-borne zoonotic agents[17], EU targets can be established for the reduction of the prevalence of *Campylobacter.* EU targets for poultry populations have already been set for the control of *Salmonella*. When defining an EU target for *Campylobacter* in poultry, the Commission shall provide an analysis of its expected costs and benefits taking into account the criteria laid down in paragraph 6(c) of Article 4 to the Regulation (EC) No 2160/2003, with regard to *Campylobacter*, in particular:

- its frequency in animal and human populations, feed and food;
- the gravity of its affects for humans;
- its economic consequences for animal and human health care and for food and feed business;
- epidemiological trends in animal and human populations, feed and food;
- scientific advice;
- technological developments, particularly relating to the practicality of the available control options; and
- requirements and trends concerning breeding and production systems.

### A1.2.2 Evolution (Scoping Paper points 8-10):

In order to establish baseline and comparable values for all Member States, an EU-wide baseline survey was carried out at slaughterhouse level to determine the prevalence of *Campylobacter* in broiler batches and carcasses thereof in accordance with Decision 2007/516/EC[18]. The results have been analysed and published by the European Food Safety Authority (EFSA) by the end of October 2009. At EU level the prevalence of *Campylobacter*-colonised broiler batches was 71.2% and that of *Campylobacter*-contaminated broiler carcasses was 75.8%. Member State prevalence varied from 2.0% to 100.0% and from 4.9% to 100.0%, for caecal contents and carcasses, respectively[19].

Additionally, the Commission requested the EFSA to draft an opinion on *Campylobacter* in the broiler meat production: control options and performance objectives and/or targets at

[17] OJ L 325, 12.12.2003, p. 1.

[18] OJ L 190, 21.7.2007, p. 25.

[19] *The EFSA Journal* 2010, 8(03):1503

different stages of the food chain. This opinion has been adopted by the Scientific Panel on Biological Hazards of EFSA in March 2010 and shall also be taken into account[20].

The EFSA opinion on the various control options was also presented for discussion to the Member States on the standing committee of the food chain on the 14th of April 2011.

## A1.3 Objectives (Scoping Paper point 2)

### A1.3.1 The contractor is asked to:

**Part A)** Estimate the cost of the most important control options for *Campylobacter* and their combinations within the broiler meat production chain (pre-harvest, at harvest and post-harvest) for a 50% and 90% reduction of the incidence of human campylobacteriosis at EU level. The criteria laid down in Article 4(6) of Regulation (EC) No 2160/2003 (ref) should be considered as well as the EFSA opinion on *Campylobacter* control options, published on 7 April 2011.

The following costs should be analysed in detail for both options to be achieved within maximum 5 years after the start of the control programme:

- cost of monitoring by food business operators. Two or three different sampling frequencies should be considered in consultation with the Commission.
- cost of monitoring by competent authorities to verify correct implementation by food business operators
- cost of different control options and combinations of control options needed to obtain the objectives (e.g. freezing, decontamination of carcases, flyscreens, vaccination, bacteriocins, scheduled slaughter, etc…)
- cost of withdrawal or recall of products taking into account realistic scenario's (e.g. potential consumption before the result is known
- expected social impact e.g. losses of sales due to loss of consumers' confidence
- impact on import of broiler meat
- reduction of human health burden (deaths, hospitalisation, treatment costs, economic losses, etc.…)

**Part B)** Develop a cost/benefit model to be used both on an EU level and by particular MSs to differentiate the cost/benefit analyses for different prevalence levels of *Campylobacter* and production chain conditions. The model should provide the most cost-efficient approach to obtain the above objectives at EU and MS level. The model shall be open for any future input of new data and conditions and be forwarded to the Commission by the end of the contract.

### 2.1.1 Methodology

The methodology of this study must be drawn by the contractor taking into account the scope and objectives. The contractor is expected to develop and implement a methodology ensuring that all aspects are sufficiently well covered and that clear conclusions can be drawn with regard to the preferred option.

The contractor is required to clearly detail the different steps of the design, summarising the methodology in a table format.

The methodology shall contain desk research, classification, mapping and review of data from the readily available resources. A limited number of direct interviews with the main stakeholders and representatives of national competent authorities may be necessary where data is not readily available or where specifically indicated by involved experts. The contractor is invited to propose a series of key indicators defined at different levels. An expert group shall be organised to discuss the draft final report.

[20] *The EFSA Journal* 2011;9(4):2105

Contractors are expected not to restrict themselves to these minimum requirements. Proposals for additional methodological tools that may contribute to meeting the objectives of the study in a more satisfactory manner will be considered positively when evaluating the proposals

## A1.4 Description of the assignment

### A1.4.1 Purpose and objective of the assignment (should be in line with the Scoping Paper's point 6)

See point 2.3.

### *A1.4.2* 3.2. Specific Tasks

Policy options:

- Description / identification (~~yes~~ / no)
- Comparison of policy options (yes ~~/ no~~)
- SWOT analysis (~~yes~~ / no)
- Cost / Benefit analysis (yes / ~~no~~)
- Cost effectiveness analysis (yes / ~~no~~)
- b) Survey / analysis of the sector (~~yes~~ / no)
- c) Data collection (~~yes~~ / no)

Analysis of impacts:

- Economic (yes / ~~no~~)
- Social (~~yes~~ / no)
- Environmental (~~yes~~ / no)
- Special focus on:
  - Likelihood - uncertainty and sensitivity analysis (~~yes~~ / no)
  - Timescale - time affecting the scale of impacts? (~~yes~~ / no)
  - Magnitude – significance of each impact (~~yes~~ / no)
  - Direct and indirect (~~yes~~ / no)
  - Inside the EU and outside the EU. (~~yes~~ / no)
  - R&D – sustainable development (~~yes~~ / no)
  - Impact on other industries / SMEs (~~yes~~ / no)
  - Compliance costs – administrative burden (yes / ~~no~~)

Quantification / Monetization of impacts (yes / ~~no~~)

Stakeholder consultation

- Preparation (~~yes~~ / no)
- Organisation (~~yes~~ / no)
- Follow - up (~~yes~~ / no)

Monitoring ex-post – establishment of core indicators (~~yes~~ / no)

Ex-ante evaluation specificities to be included in the IA (*Scoping Paper point 17*)

Other tasks …

## A1.5 Reporting and deliverables

### A1.5.1 Inception report

The evaluator must provide the Commission services with an inception report on the detailed planning of the study, including methodology, and data sources to be used. This document will present in detail how the method proposed is going to be implemented and in particular how the method will assess each element required and provide a judgement. This document will provide the Commission desk-officers with the opportunity to make a final check of the feasibility of the method proposed and the extent to which it corresponds with the information needs outlined in the terms of reference.

The inception report will be submitted at the latest 6 weeks after the signature of the contract.

### A1.5.2 Intermediate results and progress report

The evaluator must provide the Commission services with a written and oral presentation of the intermediate results of the study including a summary of the main findings for each element to be considered. This progress report will provide the inter-Service steering group with the opportunity to check whether the study is on schedule and whether the preparatory work has actually focused on the specified information needs.

This task will be carried out 3 months after the signing of the contract at latest.

### A1.5.3 Draft final report and final report

#### *A1.5.3.1 Draft final report:*

The evaluator must provide the Commission services with a written and oral presentation on the draft final results. The draft final report will provide the conclusions of the evaluator in respect to the elements to be assessed as included in the terms of reference. These conclusions will be clearly based on evidence generated through the analysis. Judgements provided should be clear, objective and explicit. This document will also contain recommendations developed on the basis of the conclusions reached by the evaluator. The structure of the draft final report will respect the structure set up by common standards and include an executive summary (synthesis of main analyses and conclusions, added value of each element), main report (presenting in full the results of the analyses, conclusions and recommendations), technical annexes, and a one-page summary on the Key Messages of the analysis carried out.

#### *A1.5.3.2 Final report*

The evaluator must provide the Commission services with a written and oral presentation on the final results at the latest 6 months after the signature of the contract. The final report will take into account the results of the internal quality assessment about the draft final report insofar as they do not interfere with the autonomy of the evaluators in respect to their conclusions. The final executive summary and Key Messages page will be part of it.

The reports and presentations will be provided in English under electronic format compatible with Commission's software. Each deliverable will be followed by a presentation in Commission's office in Brussels.

Deliverables will be submitted to the Commission experts, which may ask for complementary information or propose adjustments in order to redirect the work when necessary. Deliverables must be accepted by the Commission. With work progressing and in the light of new findings, revisions of deliverables already approved may be necessary.

Deliverables shall be drafted in a concise and easily understandable language. The presentation of the texts, tables and graphs has to be clear and complete and correspond to commonly recognised standards for studies to be published.

The volume of final deliverable text will not exceed 200 pages (Times New Roman 12 or equivalent, excluding annexes). The core text has to be concentrated on the assessment of the main study items. An executive summary of not more than five pages should be included in the final report. Background information should be presented in annexes.

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# Annex 3 Characterisation of the EU broiler sector

The annex presents data on the EU broiler sector. The following tables indicate the level of consumption, the volume and the value of production and imports.

### Table A3.1 Consumption of poultry meat* in EU MS (1000 tonnes)

| | 2008 | 2009 | 2010 |
|---|---|---|---|
| Austria | 161 | 168 | 172 |
| Belgium | | | |
| Bulgaria | | 167 | 133 |
| Cyprus | | | 35 |
| Czech Republic | | | |
| Denmark | 153 | 145 | |
| Estonia | 26 | 29 | 30 |
| Finland | | | |
| France | 1482 | 1473 | 1534 |
| Germany | | | |
| Greece | 242 | 249 | 236 |
| Hungary | 303 | 290 | 10 |
| Ireland | 126 | 115 | 116 |
| Italy | 1148 | 1159 | 1207 |
| Latvia | | | |
| Lithuania | | | |
| Luxembourg | 7 | 7 | 8 |
| Malta | | | |
| Netherlands | | | |
| Poland | | | |
| Portugal | 354 | 370 | 376 |
| Romania | 397 | 400 | 322 |
| Slovakia | 102 | 108 | 97 |
| Slovenia | 54 | | |
| Spain | | | |
| Sweden | | | |
| United Kingdom | 137 | | |

*Source: Eurostat, Food: From farm to fork statistics, gross human apparent consumption of poultry meat*

** Poultry meat includes: cocks, hens and chickens; turkeys; ducks; geese; and guinea fowl.*

Table A3.2 Production of selected poultry meat products in EU MS (2010)

| | Fresh or chilled whole chickens | Fresh or chilled cuts of chicken | Frozen whole chickens | Frozen cuts of chicken | Fresh or chilled whole chickens | Fresh or chilled cuts of chicken | Frozen whole chickens | Frozen cuts of chicken |
|---|---|---|---|---|---|---|---|---|
| | Quantity ('000 kg.) | Quantity ('000 kg.) | Quantity ('000 kg.) | Quantity ('000 kg.) | Value ('000 euros) | Value ('000 euros) | Value ('000 euros) | Value ('000 euros) |
| **Austria** | 36,968 | 31,554 | 1,919 | 3,193 | 83,599 | 111,424 | 1,969 | 4,234 |
| **Belgium** | 81,795 | 317,524 | 33,242 | 72,653 | 128,688 | 655,729 | 37,564 | 78,849 |
| **Bulgaria** | 41,143 | 18,998 | 13,819 | 43,886 | 59,414 | 38,249 | 18,256 | 55,207 |
| **Cyprus** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Czech Republic** | 48,619 | 58,782 | 10,991 | 25,612 | 84,618 | 136,472 | 17,128 | 45,560 |
| **Denmark** | 9,334 | 14,548 | 17,478 | 84,845 | 25,908 | 50,775 | 33,691 | 148,211 |
| **Estonia** | | 0 | 0 | 1 | | 0 | 0 | 22 |
| **Finland** | 128 | 7,311 | 0 | 8,910 | 362 | 29,357 | 0 | 10,475 |
| **France** | 319,715 | 279,755 | | 106,459 | 911,168 | 979,222 | 247,235 | 162,323 |
| **Germany** | 150,449 | 410,246 | 231,833 | 142,227 | 279,488 | 862,438 | 396,716 | 240,969 |
| **Greece** | 50,167 | 22,812 | 5,539 | 7,498 | 117,207 | 91,035 | 8,832 | 10,383 |
| **Hungary** | 40,046 | 96,975 | 483 | 18,231 | 54,970 | 170,709 | 677 | 19,743 |
| **Ireland** | 48,728 | 32,136 | | | 87,491 | 107,249 | | 17,907 |
| **Italy** | 448,165 | 269,715 | 4,933 | 13,832 | 862,410 | 690,002 | 10,257 | 30,892 |
| **Latvia** | | | | | | | | |
| **Lithuania** | 12,867 | 24,028 | 1,527 | 18,237 | 17,546 | 38,503 | 2,134 | 36,169 |
| **Luxembourg** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Malta** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Netherlands** | 40,094 | 781,394 | 14,056 | 180,127 | 76,058 | 1,426,812 | 19,608 | 269,856 |
| **Poland** | 574,207 | 520,619 | 11,083 | 70,221 | 704,194 | 768,610 | 13,598 | 84,546 |

| | Fresh or chilled whole chickens | Fresh or chilled cuts of chicken | Frozen whole chickens | Frozen cuts of chicken | Fresh or chilled whole chickens | Fresh or chilled cuts of chicken | Frozen whole chickens | Frozen cuts of chicken |
|---|---|---|---|---|---|---|---|---|
| | Quantity ('000 kg.) | Quantity ('000 kg.) | Quantity ('000 kg.) | Quantity ('000 kg.) | Value ('000 euros) | Value ('000 euros) | Value ('000 euros) | Value ('000 euros) |
| Portugal | 188,751 | 25,462 | 3,506 | 1,747 | 310,498 | 74,028 | 5,677 | 4,063 |
| Romania | 115,210 | 63,904 | 37,491 | 77,874 | 170,922 | 105,514 | 51,272 | 116,041 |
| Slovakia | 17,212 | 19,441 | 6,477 | 11,662 | 26,863 | 43,765 | 8,909 | 19,407 |
| Slovenia | | | | | | | | |
| Spain | 789,524 | 373,243 | 17,448 | 66,998 | 1,126,938 | 871,266 | 19,207 | 108,129 |
| Sweden | 29,901 | 16,168 | 5,793 | 50,156 | 66,954 | 69,627 | 10,408 | 156,221 |
| United Kingdom | 623,888 | 367,417 | 12,370 | 89,607 | 1,085,613 | 1,369,593 | 17,881 | 109,061 |
| Total | 3,666,911 | 3,752,032 | 429,988 | 1,093,975 | 6,280,909 | 8,690,380 | 921,017 | 1,728,269 |

*Source: Eurostat, Prodcom*

## Table A3.3 Extra-EU imports for selected poultry meat products in EU MS (2011)

| | Fresh or chilled fowls of the species gallus domesticus (not cut in pieces) | Fresh or chilled cuts and edible offal of fowls of the species gallus domesticus | Frozen fowls of the species gallus domesticus (not cut in pieces) | Frozen cuts and edible offal of fowls of the species gallus domesticus | Fresh or chilled fowls of the species gallus domesticus (not cut in pieces) | Fresh or chilled cuts and edible offal of fowls of the species gallus domesticus | Frozen fowls of the species gallus domesticus (not cut in pieces) | Frozen cuts and edible offal of fowls of the species gallus domesticus |
|---|---|---|---|---|---|---|---|---|
| | Quantity ('00 kg.) | Quantity ('00 kg.) | Quantity ('00 kg.) | Quantity ('00 kg.) | Value (euros) | Value (euros) | Value (euros) | Value (euros) |
| **Austria** | 1 | 1,038 | 1,043 | 3,673 | 27 | 335,489 | 181,215 | 1,532,128 |
| **Belgium** | | | 498 | 16,688 | | | 119,693 | 4,631,929 |
| **Bulgaria** | | | 210 | 39,199 | | | 25,200 | 2,457,497 |
| **Cyprus** | | | 8,522 | 7,868 | | | 1,114,675 | 2,236,045 |
| **Czech Republic** | | | 250 | 26,206 | | | 31,331 | 1,768,560 |
| **Denmark** | | 1,688 | 510 | 3,143 | | 1,060,717 | 73,424 | 1,643,521 |
| **Estonia** | | | | | | | | |
| **Finland** | | | | | | | | |
| **France** | 0* | 0* | 90 | 39,512 | 315* | 153* | 23,915 | 9,288,641 |
| **Germany** | | | 8,176 | 104,588 | | | 1,086,017 | 20,627,455 |
| **Greece** | | 0* | 774 | 256 | 0 | 0* | 181,985 | 74,256 |
| **Hungary** | | | | 9,536 | | | | 684,499 |
| **Ireland** | | 2* | | 17,018 | | 1,014* | | 3,523,849 |
| **Italy** | | | 2,177 | 22,048 | | | 303,348 | 5,843,443 |
| **Latvia** | | | | | | | | |
| **Lithuania** | | | | | | | | |
| **Luxembourg** | | | | | | | | |

| | Fresh or chilled fowls of the species gallus domesticus (not cut in pieces) | Fresh or chilled cuts and edible offal of fowls of the species gallus domesticus | Frozen fowls of the species gallus domesticus (not cut in pieces) | Frozen cuts and edible offal of fowls of the species gallus domesticus | Fresh or chilled fowls of the species gallus domesticus (not cut in pieces) | Fresh or chilled cuts and edible offal of fowls of the species gallus domesticus | Frozen fowls of the species gallus domesticus (not cut in pieces) | Frozen cuts and edible offal of fowls of the species gallus domesticus |
|---|---|---|---|---|---|---|---|---|
| | Quantity ('00 kg.) | Quantity ('00 kg.) | Quantity ('00 kg.) | Quantity ('00 kg.) | Value (euros) | Value (euros) | Value (euros) | Value (euros) |
| **Malta** | | 0 | 2,506 | 75* | | 93 | 354,468 | 17,809* |
| **Netherlands** | | 1,789 | 3,987 | 600,301 | | 17,768 | 509,611 | 130,067,236 |
| **Poland** | | | | 208* | | | | 29,176* |
| **Portugal** | | 0 | 251 | 3,552 | | 249 | 37,922 | 802,308 |
| **Romania** | | | 763* | 112,078 | | | 99,275* | 7,386,692 |
| **Slovakia** | | | | 7,526 | | | | 548,444 |
| **Slovenia** | | 78 | | 807 | | 28,574 | | 162,632 |
| **Spain** | | | 25,661 | 277,631 | | | 3,702,224 | 50,287,876 |
| **Sweden** | | 241* | 85 | 1,168 | | 891* | 11,047 | 308,977 |
| **United Kingdom** | 2 | | 72,193 | 155,026 | 1,007 | | 9,777,909 | 44,185,799 |
| **Total** | 3 | 4,836 | 127,696 | 1,448,107 | 1,349 | 1,444,948 | 17,633,259 | 288,108,772 |

*Source: Eurostat, Comext*

** 2010 data*

Table A3.4 Intra-EU imports for selected poultry meat products in EU MS (2011)

| | Fresh or chilled fowls of the species gallus domesticus (not cut in pieces) | Fresh or chilled cuts and edible offal of fowls of the species gallus domesticus | Frozen fowls of the species gallus domesticus (not cut in pieces) | Frozen cuts and edible offal of fowls of the species gallus domesticus | Fresh or chilled fowls of the species gallus domesticus (not cut in pieces) | Fresh or chilled cuts and edible offal of fowls of the species gallus domesticus | Frozen fowls of the species gallus domesticus (not cut in pieces) | Frozen cuts and edible offal of fowls of the species gallus domesticus |
|---|---|---|---|---|---|---|---|---|
| | Quantity ('00 kg.) | Quantity ('00 kg.) | Quantity ('00 kg.) | Quantity ('00 kg.) | Value (euros) | Value (euros) | Value (euros) | Value (euros) |
| Austria | 31,697 | 317,254 | 6,911 | 102,993 | 6,531,159 | 57,856,157 | 1,318,688 | 19,253,250 |
| Belgium | 83,324 | 581,132 | 36,407 | 711,608 | 27,344,843 | 84,911,201 | 5,029,889 | 76,487,740 |
| Bulgaria | 123,304 | 197,324 | 73,666 | 480,536 | 15,953,049 | 37,472,863 | 10,016,572 | 66,242,509 |
| Cyprus | 1,589 | 635 | 13,506 | 26,162 | 316,419 | 149,455 | 2,064,360 | 5,187,158 |
| Czech Republic | 109,216 | 149,418 | 18,285 | 416,367 | 17,258,605 | 36,148,712 | 2,569,640 | 82,516,910 |
| Denmark | 23,874 | 97,455 | 28,970 | 290,021 | 6,178,565 | 30,006,439 | 4,882,725 | 41,584,025 |
| Estonia | 9,773 | 33,286 | 819 | 137,784 | 1,449,338 | 5,876,715 | 108,229 | 13,459,285 |
| Finland | 356 | 7,050 | 1,244 | 22,249 | 129,939 | 2,451,930 | 270,183 | 7,809,946 |
| France | 134,722 | 1,577,683 | 161,135 | 1,260,369 | 24,253,988 | 358,794,687 | 26,846,274 | 249,676,423 |
| Germany | 230,030 | 1,863,712 | 117,586 | 900,407 | 49,122,991 | 319,808,832 | 13,694,717 | 204,788,328 |
| Greece | 123,521 | 146,044 | 23,167 | 144,693 | 25,736,341 | 30,397,436 | 4,279,780 | 28,616,354 |
| Hungary | 7,878 | 220,574 | 1,264 | 90,769 | 1,107,764 | 23,866,017 | 211,361 | 9,376,851 |
| Ireland | 48,657 | 272,422 | 13,769 | 102,485 | 17,988,440 | 91,021,660 | 5,163,911 | 30,028,632 |
| Italy | 72,286 | 114,983 | 39,447 | 157,225 | 11,898,180 | 28,992,383 | 8,220,784 | 26,199,143 |
| Latvia | 38,692 | 98,281 | 11,704 | 123,753 | 6,266,478 | 11,213,502 | 2,032,894 | 12,984,628 |
| Lithuania | 61,387 | 66,428 | 2,370 | 74,319 | 8,465,432 | 7,534,065 | 453,764 | 7,860,809 |
| Luxembourg | 23,005 | 28,357 | 1,133 | 5,162 | 8,737,638 | 10,710,105 | 244,130 | 1,790,354 |

| | Fresh or chilled fowls of the species gallus domesticus (not cut in pieces) | Fresh or chilled cuts and edible offal of fowls of the species gallus domesticus | Frozen fowls of the species gallus domesticus (not cut in pieces) | Frozen cuts and edible offal of fowls of the species gallus domesticus | Fresh or chilled fowls of the species gallus domesticus (not cut in pieces) | Fresh or chilled cuts and edible offal of fowls of the species gallus domesticus | Frozen fowls of the species gallus domesticus (not cut in pieces) | Frozen cuts and edible offal of fowls of the species gallus domesticus |
|---|---|---|---|---|---|---|---|---|
| | Quantity ('00 kg.) | Quantity ('00 kg.) | Quantity ('00 kg.) | Quantity ('00 kg.) | Value (euros) | Value (euros) | Value (euros) | Value (euros) |
| Malta | 2,529 | 6,223 | 4,444 | 32,080 | 600,945 | 1,729,631 | 838,903 | 7,705,437 |
| Netherlands | 64,952 | 13,356,240 | 124,476 | 17,671,090 | 12,921,185 | 215,210,679 | 14,757,861 | 122,207,826 |
| Poland | 8,704 | 76,532 | 9,885 | 71,531 | 1,209,398 | 4,445,618 | 1,579,356 | 11,298,589 |
| Portugal | 55,210 | 36,627 | 19,871 | 144,290 | 8,803,103 | 8,091,315 | 4,262,466 | 21,178,188 |
| Romania | 115,164 | 83,125 | 15,153 | 440,868 | 13,178,129 | 9,970,080 | 1,600,957 | 55,182,308 |
| Slovakia | 22,927 | 108,428 | 40,426 | 171,375 | 4,550,623 | 23,454,668 | 4,982,443 | 63,861,233 |
| Slovenia | 6,736 | 40,252 | 19,015 | 15,633 | 1,573,084 | 8,375,232 | 2,072,947 | 2,759,092 |
| Spain | 90,195 | 184,365 | 75,559 | 224,875 | 19,196,392 | 56,123,027 | 12,865,159 | 41,674,031 |
| Sweden | 7,591 | 37,194 | 15,236 | 280,530 | 1,594,463 | 11,507,745 | 3,695,762 | 97,923,988 |
| United Kingdom | 323,539 | 1,941,478 | 77,301 | 1,139,895 | 67,785,293 | 619,237,838 | 19,249,963 | 333,735,760 |
| Total | 1,820,858 | 21,642,502 | 952,749 | 25,239,069 | 360,151,784 | 2,095,357,992 | 153,313,718 | 1,641,388,797 |

*Source: Eurostat, Comext*

## Table A3.5 EU exports to major partners (2011)

| | Fresh or chilled fowls of the species gallus domesticus (not cut in pieces) | Fresh or chilled cuts and edible offal of fowls of the species gallus domesticus | Frozen fowls of the species gallus domesticus (not cut in pieces) | Frozen cuts and edible offal of fowls of the species gallus domesticus |
|---|---|---|---|---|
| | Value (euros) | Value (euros) | Value (euros) | Value (euros) |
| Hong Kong | 93,063 | 4,299,852 | 918,331 | 122,687,139 |
| Benin | 659,261 | 2,533,582 | 28,509,494 | 67,174,352 |
| Switzerland | 2,413,044 | 40,567,166 | 378,739 | 4,833,677 |
| Ghana | 91,956 | 3,280,855 | 3,433,652 | 39,425,442 |
| Russian Federation | 36,708 | 69,531 | 1,191,186 | 38,294,463 |
| Malaysia | 3,510 | 566,959 | 1,641 | 28,027,579 |
| United Arab Emirates | 141,990 | 444,785 | 22,425,378 | 1,279,803 |
| Jordan | 4,059 | 127,856 | 21,090,339 | 201,739 |
| Others | 11,504,879 | 33,338,657 | 357,646,257 | 276,971,732 |
| Total | 14,948,470 | 85,229,243 | 435,595,017 | 578,895,926 |

*Source: Eurostat, Comext*

## Table A3.6 Indicators of the capacity and structure of production sector

| | Number of holdings (2007) | Number of broilers in holdings (2007) (1000 heads) | Average days to slaughter | Number of slaughtering chickens (2010) (1000 heads)* | The weight of slaughtering chi (2010) (thousar tonnes) |
|---|---|---|---|---|---|
| Austria | 1,340 | 6,840 | 35.6 | 72,310 | 97 |
| Belgium | 1,090 | 20,160 | 43.0 | 306,797 | 497 |
| Bulgaria | 17,480 | 7,740 | 45.7 | 46,451 | 73 |
| Cyprus | 3,740 | 3,090 | 50.1 | 13,736 | 27 |
| Czech Republic | 600 | 18,910 | 37.9 | 132,755 | 183 |
| Denmark | 290 | 11,760 | 37.8 | 107,151 | 184 |
| Estonia | 170 | 860 | 39.3 | 9,619 | 16 |
| Finland | 140 | 5,070 | 37.8 | 53,432 | 87 |
| France | 60,510 | 125,910 | 50.5 | 789,185 | 1,037 |
| Germany | 9,000 | 61,310 | 36.3 | 591,180 | 803 |
| Greece | 166,280 | 24,470 | - | 115,369 | 176 |
| Hungary | 770 | 9,780 | 43.9 | 119,389 | 208 |
| Ireland | 950 | 8,330 | 40.8 | 77,539 | 109 |
| Italy | 52,220 | 93,260 | 49.2 | 491,360 | 865 |
| Latvia | 470 | 1,710 | 41.1 | 15,101 | 23 |
| Lithuania | 19,180 | 3,850 | 42.3 | 37,777 | 64 |
| Luxembourg | 170 | 20 | 80.0 | 0 | 0 |
| Malta | 230 | 660 | 45.7 | 2,682 | 4 |

| | Number of holdings (2007) | Number of broilers in holdings (2007) (1000 heads) | Average days to slaughter | Number of slaughtering chickens (2010) (1000 heads)* | The weight slaughtering chi (2010) (thousan tonnes) |
|---|---|---|---|---|---|
| **Netherlands** | 750 | 43,350 | 41.2 | 479,015 | 781 |
| **Poland** | 633,120 | 85,960 | 44.3 | 591,907 | 1,000 |
| **Portugal** | 101,140 | 15,580 | 39.8 | 179,605 | 249 |
| **Romania** | 2,175,310 | 28,790 | 40.7 | 175,825 | 286 |
| **Slovakia** | 1,100 | 7,660 | 39.3 | 41,956 | 64 |
| **Slovenia** | 3,000 | 3,430 | 39.1 | 29,437 | 55 |
| **Spain** | 65,170 | 89,610 | 47.8 | 585,842 | 1,116 |
| **Sweden** | 210 | 6,650 | 35.4 | 78,507 | 112 |
| **United Kingdom** | 1,830 | 108,740 | 41.2 | 905,030 | 1,379 |
| **Total** | 3,316,260 | 793,500 | - | 6,048,956 | 9,495 |

*Notes and sources:*

*i) Eurostat; ii) National Statistics Offices; iii) EFSA Journal 2010; 8(03):1503*

**Figure includes both indoor and outdoor.*

## Table A3.7 Economic aspects of broiler production market

| | Average farm gate sale weight (kg)* | Price of live chicken (from producer to trade) (2010) (euros per 100 kg) | Average labour cost per hour (euros)** |
|---|---|---|---|
| **Austria** | 2.078 | 91.6 | 15.78 |
| **Belgium** | 2.737 | 86.2 | 8.46 |
| **Bulgaria** | 2.978 | 92.5 | 0.73 |
| **Cyprus** | 3.353 | 174.2† | 13.50 |
| **Czech Republic** | 2.283 | 80.6 | 1.92 |
| **Denmark** | 2.274 | 74.3 | 20.57 |
| **Estonia** | 2.413 | 102.2† | 1.65 |
| **Finland** | 2.270 | 93† | 9.50 |
| **France** | 3.389 | 104.3† | 9.00 |
| **Germany** | 2.134 | 81.0 | 10.50 |
| **Greece** | - | 149.6 | 5.15 |
| **Hungary** | 2.821 | 77.6 | 1.70 |
| **Ireland** | 2.548 | 86.1 | 8.65 |
| **Italy** | 3.283 | 105.0 | 8.00 |
| **Latvia** | 2.572 | 123.1† | 1.67 |
| **Lithuania** | 2.680 | 82.1 | 1.37 |
| **Luxembourg** | - | 318.0 | 10.40 |
| **Malta** | 2.979 | 118.8 | 3.93 |
| **Netherlands** | 2.576 | 78.8 | 8.46 |
| **Poland** | 2.859 | 80.2 | 2.06 |
| **Portugal** | 2.450 | 43.2 | 3.35 |
| **Romania** | 2.536 | 92.1 | 0.93 |
| **Slovakia** | 2.406 | 78.8 | 1.88 |
| **Slovenia** | 2.391 | 102.4 | 4.43 |
| **Spain** | 3.159 | 97.6 | 4.43 |
| **Sweden** | 2.054 | 90.0 | 13.50 |
| **United Kingdom** | 2.577 | 91.2†† | 6.58 |

*Notes and sources:*

*i) Eurostat; ii) National Statistics Offices; iii) EFSA Journal 2010; 8(03):1503*

**Data on average farm gate sale weight is based on the Ross 308 broiler bird which is widely used.*

***Average hourly labour cost in farming and slaughtering: due to lack of data minimum wage figures have been extracted as the best estimate for the labour cost.*

*For 7 EU MS where minimum wage is not available (AT, CY, DK, DE, FI, IT, SE) data for average hourly salary in agriculture have been extracted from the databases of the national statistical offices.*

*†FAOSTAT, 2009 data*

††Based on correspondence from J. Gittins and J. Newton (2012) who assume a price of GBP 76/100kg for 2011.

**Table A3.8 Country data on economic aspects of production and preserving of poultry meat (2008)**

| | Number of persons employed in production and preserving of poultry meat* | Number of enterprises in production and preserving of poultry meat* | Turnover in production and preserving of poultry meat* |
|---|---|---|---|
| Austria | 860 | 15 | 187 |
| Belgium | 2,497 | 111 | 1,185 |
| Bulgaria | 4,845 | 83 | 253 |
| Cyprus | 319 | 14 | 53 |
| Czech Republic | 3,715** | 35** | 333** |
| Denmark | | 5 | |
| Estonia | | 1 | |
| Finland | 99** | 2 | 24** |
| France | 29,898** | 599 | 6,728 |
| Germany | 9,884 | 80 | 4,149 |
| Greece | 1,540** | 38** | 247** |
| Hungary | 9,772 | 114 | 865 |
| Ireland | 1,559 | 11 | 337 |
| Italy | 12,005 | 286 | 2,610 |
| Latvia | 1,129 | 3 | |
| Lithuania | 28 | 3 | 2 |
| Luxembourg | 0 | 0 | 0 |
| Malta | | | |
| Netherlands | 2,817 | 52 | 1,956 |
| Poland | 22,981 | 333 | 2,860 |
| Portugal | 3,524 | 57 | 553 |
| Romania | 5,145** | 50** | 190** |
| Slovakia | 2,045 | 8 | 164 |
| Slovenia | 1,478 | 3 | 176 |
| Spain | 10,357 | 190 | 2,448 |
| Sweden | 1,523 | 27 | 331 |
| United Kingdom | 22,455** | 123 | 4,178 |
| Total | 150,475 | 2,243 | 29,827 |

*Notes and sources:*

*Eurostat*

** Section C - Manufacturing, NACE 10.12, including: - operation of slaughterhouses engaged in killing, dressing or packing poultry; - production of fresh, chilled or frozen meat in individual portions; - rendering of edible poultry fats.*

*** 2007 figures.*

# Annex 4 Intervention options

This annex provides a detailed description of the options that have been assessed.

## A4.1 Farm level controls

### A4.1.1 F1 – Enhanced bio-security

Bio-security consists of preventative measures to reduce the risk of transmission of infectious agents into the poultry house. Vertical transmission has been excluded as a route of *Campylobacter* colonisation in poultry so transmission through horizontal routes, i.e. from the contaminated outside environment, is considered most likely. The potential sources of such contamination have been systematically reviewed (Newell et al., 2011).

Human traffic is an important vehicle by which *Campylobacter* is introduced into poultry houses. The recommended minimum requirements for biosecurity in conventional houses includes an anteroom with hygiene barrier (with adequate boot dips and hand wash facilities), a rodent-free and concrete hard surround with no standing water, mains water supply or treated well water, the exclusion of pets and control of visitors (EIO, 2011). However, evidence indicates that this level of biosecurity is generally insufficient to exclude *Campylobacter*. Therefore, additional measures to provide enhanced biosecurity need to be taken. Such measures could range from use of fly screens to shower in by farm staff. The relative importance of such measures are currently unknown. As the options are many only some specific measures, which might contribute to enhanced biosecurity are considered as examples, these include:

a) The use of house-specific footwear and outer clothing,

b) External training for farm managers on biosecurity and internal training conducted by farm managers for stockmen.

In addition, the use of fly screens could be considered as complementary to the above enhanced bio-security measures but the evidence for this to be successful is currently limited to studies from one MS. As such this option has not been included in the assessment of costs for F1 but there is an option to include in the model as appropriate by MS.

**Table A4.1 Option F1 – Enhanced bio-security**

| | |
|---|---|
| **Baseline (current status)** | ▪ EU baseline is not known and difficult to determine. The highest levels of biosecurity (containment level 2) can produce 100% *Campylobacter* –free flocks but such levels are impractical at the farm. Risk will vary with management practices, season and level of environmental contamination. Lowest risk should be winter when successful biosecurity should be easiest to achieve. Biosecurity to exclude *Campylobacter* is an impractical measure for free range flocks because of environmental contamination. |
| **Impact on prevalence & evidence thereof** | ▪ Good bio-security reduces prevalence of *Campylobacter* positive house but once a house becomes positive then all birds in the house are positive and further good biosecurity achieves no extra benefit to that house but may prevent cross-contamination to other houses on the same site.<br>▪ It is widely assumed that farm workers and other visitors and other equipment pose a significant risk. Molecular tracking studies have linked *Campylobacter* -positive boots and other clothing worn by workers as a direct cause of subsequent flock colonisation. The sources of such personnel contamination have been identified as puddles and other surface waters, farm vehicles, and other livestock on or near the farm (Newell et al., 2011). |

| | |
|---|---|
| | ▪ Experimental evidence for sources of contamination have been historically based on risk factor studies variable but recent evidence is based on molecular epidemiology is more convincing.<br>▪ Very difficult to estimate% reduction due to variation in compliance by farmers and in efficacy relative to geography, season and environment; Only one intervention study has been published to date (Gibbens *et al*., 2001) suggesting an approximately up to 50% reduction in flock prevalence by stringent use of house-dedicated boots and hand washing in addition to minimal biosecurity measures. However this was in the UK only and such measures would be routine in other MS. |
| **Costs** | ■ Costs can be estimated for individual component elements such as workers clothing, training etc. For example:<br>▪ Provision of dedicated changing facilities would cost in the order of € 1,500[21] per house.<br>▪ Extra changing time of 30 minutes per day based on average of 3 visits per house – this equates €10/day/house. For a system with 7 batches of 42 week production, this equates to an extra annual cost of €2,940.<br>▪ The cost of providing training in biosecurity to farm managers and other key staff associated with broiler production is estimated to be €0.34 per 1000 bird spaces. This is based on a combination of initially using external specialists and subsequently cascading the training using in-house staff e.g. farm managers to train farm staff.<br>▪ Fitting a single flyscreen door to the access door of a broiler house would cost in the region of €350[22]. Fly-proofing air inlets and outlets would not be a practical option due to the rapid build-up of dust on the screens with the concomitant adverse effect on ventilation rates. |

### A4.1.2 F2 – Restriction of slaughter age

The analysis of the pooled caecal contents from the EU baseline survey (EFSA, 2010) indicated that the age of the birds at slaughter was a risk factor in terms of increasing prevalence of *Campylobacter* colonization of broiler batches per 10 days of age.  The risk of colonization by *Campylobacter* increases approximately by a factor of two for every 10 days that the birds are older. The multivariate model accounted for concurrent effects of thinning and season.   Based on the results of four countries, up to 50% risk reduction can be achieved by restriction of slaughter age of indoor flocks to a maximum of 28 days. Since the prevalence of flock positivity is directly related to slaughter age, slaughtering at a younger age should be an effective intervention.

Timescales for this appraisal do not allow for breeders to compensate for impact on size of birds available to the market; however, the analysis will assume a production response (over time) rather than a price effect.  Production units are assumed to make up the supply through increased number of batches per annum and/or additional houses. However, it should be noted that increasing the number of houses on a farm will increase the risk of flock colonisation.

[21] FSA research project B15020 (2008)

[22] Flyscreen Company, UK (2102)

Table A4.1 Option F2 – Restriction of slaughter age

| | |
|---|---|
| **Baseline (current status)** | ▪ The EU baseline survey (EFSA, 2010) indicates a minimum of 20 days, a maximum of 150 days, and a mean of 41.4 days. |
| **Impact on prevalence & evidence thereof** | ▪ 50% reduction for 28 day limit (based on results from four countries) |
| **Costs** | ▪ Costs will vary according to the variance from the current production model. In some Member States, birds are already slaughtered at ages similar to that indicated in this option.<br>▪ Where there is variance there could be significant impacts on the farm business model (production cycle will change, revenues, access to markets) and on down the supply chain as access to larger (older) birds is curtailed. |

### A4.1.3 F3 – Discontinue thinning

Many farmers partially depopulate or "thin" flocks, which can involve the removal of a proportion (up to a third) of the flock 1-3 weeks prior to slaughter of the remainder of the flock (in some cases, thinning can be at 50% i.e. all females and could be slightly less than 7 days). Thinning during the rearing period allows increased weight gain in the remaining birds. Council Directive 2007/43/EC9 proposes a maximum stocking density in a holding or in a house of a holding lower than 33 kg /$m^2$. The implementation of this regulation probably encourages the thinning of birds during the rearing period[23].

The process of thinning entails bringing catchers and equipment into the poultry house. Frequently these are based at the processing plant. If these are contaminated with *Campylobacter*, the chance of transmitting it to the house environment and to the flock may be substantial, depending on the hygienic measures taken. Several surveys have found a statistically significant risk associated with thinning.

Discontinuing thinning would reduce the risk of *Campylobacter* introduction into a house, both due to the lowering of the slaughter age of one or more slaughter batches and due to the reduced traffic into the house during the life span of the flock. However discontinuing the process would have a significant cost impact in those countries where thinning is widely practiced and could seriously undermine the competitiveness of those MS affected, both in terms of inter-community competition and (more significantly) in competition with third countries.

Table A4.1 Option F3 – Discontinue thinning

| | |
|---|---|
| **Baseline (current status)** | ▪ A baseline value of 10% has been used for all MS with the exception of Sweden (95%) |
| **Impact on prevalence & evidence thereof** | ▪ 25% (Source: *EFSA Scientific Opinion on control options*)<br>▪ Thinning is generally regarded to be a major risk factor. The time between thinning and final depopulation is likely to be an important factor because the observation of flock positivity can take a few days. |

[23] EFSA Scientific Opinion on control options.

| | | |
|---|---|---|
| **Costs** | ▪ | Costs will vary according to the variance between what is produced and the current production model. |
| | ▪ | Member States where birds are slaughtered at a young age would experience lesser impacts than those where some of the flock is thinned. It is understood that some EU MS (e.g. DK, SE) have already banned thinning. |
| | ▪ | Where there is variance, there could be significant impacts on the farm business model (production cycle and stocking rates will change, revenues, access to markets) and on down the supply chain as (a) either access to larger (older) birds is curtailed (b) birds scheduled to be grown to a larger size have to be reared at lower initial density and thus would be expected to incur higher unit costs. |

### A4.1.4 F4 - Vaccination

A vaccination intervention measure is the use of live, killed or subunit vaccines to reduce or prevent *Campylobacter* colonisation. No vaccine is currently available specific to *Campylobacter* in poultry but there is evidence that immunity against *Campylobacter* in chickens is at least partly protective, i.e. maternal antibodies delay infection from environmental challenge for up to 3 weeks. However, the bacteriological challenge once the first bird becomes positive will almost certainly overcome any immunity in vaccinated birds. Nevertheless, vaccination may reduce colonisation levels or enhance the speed of elimination of colonisation.

*Campylobacter* strains are antigenically very diverse so vaccine would need to be multivalent or directed against conserved antigens. Vaccines needed for mass distribution, probably via water or aerosol  The vaccine also needs to generate an effective immune response in the lag phase window, i.e. the first 3 weeks of life before flock becomes positive while bird immunity is immature and in the presence of maternal antibodies.. The current strategy thought most likely to be developed commercially involves expression of *Campylobacter* antigens in live *Salmonella*. Because this is a patented process the cost of a commercial product may be high and such genetically engineered vaccines may not be acceptable.

**Table A4.1 Option F4 – Vaccination**

| | | |
|---|---|---|
| **Baseline (current status)** | ▪ | No commercially available vaccine available for *Campylobacter*. |
| **Impact on prevalence** | ▪ | Unknown. Vaccine needs to prevent the first bird in flock becoming positive to impact flock prevalence.  However there may also be an impact on carcass contamination levels as gut colonisation could be reduced. |
| **Cost of implementation** | ▪ | Vaccine would be administered via water but cannot be administered at the same time as vaccination for Salmonella (vaccination for Salmonella is targeted at the parent/grandparent flocks to prevent vertical transmission. *Campylobacter* vaccination can be undertaken at the same time as other vaccines such as against Newcastle, Marke’s and Gambaro diseases. |

### A4.1.5 F5 - Bacteriocins

*Campylobacter* specific bacteriocins are in trials and not commercially available. There are also some practical issues around timing; bacteriocins should be applied 3 days before slaughtering while the farmer knows that the animal will be slaughtered only 24h before slaughtering.

**Table A4.1 Option F5 – Bacteriocins**

| | |
|---|---|
| **Baseline (current status)** | ▪ Not in use. |
| **Impact on prevalence** | ▪ Unknown. Depends on the dose – this needs to be sufficient to kill all *Campylobacter* to prevent possible resistance evolving. |
| **Cost of implementation** | ▪ Costs could be estimated from bacteriocins used currently in cheese treatment.<br>▪ Current bacteriocins require considerable purification which might increase costs. |

### A4.1.6 Pre-slaughter testing

Testing of batches prior to slaughter would enable the selected treatment / decontamination of batches at the slaughtering and processing stage. This will involve mandatory testing of flocks on a batch basis prior slaughter with a sampling regime to match that used in the EFSA Baseline survey. The test cannot be done together with Salmonella as this is done 1-2 weeks before slaughter.

**Table A4.1 Option T1 – Pre-slaughter testing**

| | |
|---|---|
| **Baseline (current status)** | ▪ Currently no pre-slaughter mandatory testing for *Campylobacter* in place in the EU. |
| **Impact on prevalence & evidence thereof** | ▪ No direct impact but enables tactical use of other control options for infected batches at the slaughtering and processing stage. |
| **Costs** | ▪ There is a need for rapid screening test - the PCR test is the most appropriate. Cost estimated vary from €10 - €30 per pooled sample tested[24]<br>▪ Incidence of cost will depend on contracts but is likely to fall to producers (farms). Slaughterhouses may also incur costs in the receipt and processing of data. (Note: impacts of positive test on processing are considered in Six Options below).<br>▪ Potential for very small additional costs to be incurred by Competent Authorities in checking FBOs' compliance with the testing regime (unit time costs available from Commission survey) but ideally will be driven by FBOs. |

## A4.2 Slaughtering and processing controls

This section gives a specification of the options that will be applied at the slaughtering and processing stage of the supply chain. It is recognised from various studies that the standards of hygiene at slaughter and processing are very variable. The application of decontamination or treatment options (S2-S5) could in principle be applied either on a mandatory basis or on

[24] Mangen et al (2005): Controlling Campylobacter in the Chicken Meat Chain - Estimation of Intervention Costs. Agricultural Economics Research Institute, The Hague, NL.

a selective basis, according to information provided by the pre-slaughter testing. Decontamination is considered a supplement and not a substitute to good hygiene practices.

No chemical decontamination treatments are currently authorized in the EU but some chemicals are used in a number of other countries worldwide. Physical treatments like freezing and heat treatment, however, are applied in some countries in Northern Europe[25].

There is a risk that flocks which tested negative under option T1 would become positive for *Campylobacter* between the time that they were tested and when the flock was slaughtered (the testing would typically occur just prior to slaughter). Such batches ought to in principle be identified by the post-processing test (T2), with the option of product recall if *Campylobacter* exceeds threshold tolerances.

Slaughtering and processing is here treated as one step in the supply chain. It is recognised that these two operations may be carried out at different facilities. 'Processing' here refers to butchering and preparation of the carcass or joints thereof, rather than (for example) the processing of meat into cooked products or into otherwise processed products ready for sale.

### A4.2.1 S1 – Good hygiene

Good hygiene would be based on HACCP and GMP principles being developed and implemented and may consist of:

- Optimising hygienic design of equipment to prevent spillage of intestinal contents, This is likely to require investment in newer, better hygienically designed equipment
- Training of slaughter house personnel in good hygiene practices to provide more skilled and motivated workforce.

Currently there is no definitive definition of what constitutes good hygiene practice but assessment of plant hygiene is currently made by enforcement officers who enforce Regulation (EC) 854/2004 laying down specific rules for the organisation of official controls on products of animal origin intended for human consumption

**Table A4.1 Option S1 – Good hygiene**

| | |
|---|---|
| **Baseline (current status)** | ▪ Unknown. All MS have strict hygiene measures and inspection regimes but application varies. Baseline levels very difficult to determine. |
| **Impact on prevalence & evidence thereof** | ▪ Not specified. Efficacy also difficult to determine, especially due to interaction of various factors at processing level. |
| **Costs** | ▪ Capital costs relating to reinvestment in plant. For this study it has been assumed that investment is made on a 7-year cycle rather a 10-year cycle. The additional cost has been discounted at 4% and is estimated at €13 per 1000 birds.<br>▪ Training can be organised once a year (duration about an hour). Yearly cost is about €1000-2000. |

### A4.2.2 S2 – Chemical decontamination

This control option involves the decontamination of the carcass by dipping in a solution of 2.5% lactic acid and 10% trisodium phosphate (TSP).Chemical decontamination processes can reduce levels of *Campylobacter* on carcasses. It might be applied either as (a)

[25] Source: EFSA Scientific Opinion on control options.

mandatory application of chemical decontamination or more likely (b) selective application of chemical decontamination on a batch basis based on results of test T1.

A key issue to be explored is the impact on product value (revenue effects) and consumer perceptions.

**Table A4.1 Option S2 – Chemical decontamination**

| | |
|---|---|
| **Baseline (current status)** | ▪ Not currently applied in the EU. |
| **Impact on prevalence & evidence thereof** | ▪ Experimental results on efficacy provided in EFSA Scientific Opinion on control options (page 44, 45). 37-56% for lactic acid, 67-84% for TSP.<br>▪ Application on selective basis will reduce total risk reduction because of potential for flock to turn positive between test and slaughter |
| **Costs** | ▪ Not specified. Some partial data from consultations, including:<br>▪ Dipping tank (e.g. ≈ €110,000 - €150,000 per tank), spraying cabinet (e.g. ≈ €38,000 per cabinet)<br>▪ Chemical liquid consumption (e.g. lactic acid and TSP ≈ €1.5 - €2.5 per kg)<br>▪ Measure includes the decontamination of the carcass by dipping only in solution of 2.5% lactic acid and 10% trisodium phosphate (TSP). |

### A4.2.3 S3 – Freezing

The EFSA Control Options paper reports that freezing to about -20°C for a few weeks is already used to treat carcasses from *Campylobacter* colonized flocks in a few countries, and that it reduces numbers by about 2 log10 cycles with minimal impact on the appearance and quality of the meat. Widespread use of this technique would require expanded cold storage facilities, and the increased cost of frozen storage. Half of farm business organisations (FBOs) outsource the freezing, while the remainder have on-site freezing facilities.

This control option would involve broiler meat being frozen after slaughter (i) for a minimum of 2-3 days or (ii) to point of sale/preparation. It might be applied either as (a) mandatory application of freezing or more likely (b) selective application of freezing on a batch basis based on results of pre-slaughter tests.

**Table A4.1 Option S3 – Freezing**

| | |
|---|---|
| **Baseline (current status)** | ▪ EFSA Opinion reports that freezing is applied in some countries in Northern Europe[26]. Currently awaiting data. |
| **Impact on prevalence & evidence thereof** | ▪ More than 90% risk reduction can be obtained by freezing carcasses for 2-3 weeks. A 50-90% risk reduction can be achieved by freezing for 2-3 days (source: EFSA Scientific Opinion on control options)<br>▪ Application on selective basis will reduce total risk reduction because of potential for a flock to turn positive between test and slaughter. |

[26] EFSA, Scientific Opinion on *Campylobacter* in broiler meat production: control options and performance objectives and/or targets at different stages of the food chain; 2001; 9(4):2105.

| | |
|---|---|
| **Costs** | ■ Costs would relate to (a) capital costs for freezing infrastructure and cold storage (b) operating costs of freezing units. Some partial data from consultations, including:<br>▪ Capital purchase costs, installation and reorganisation costs are somewhere between €1.5 and €3 million per piece of equipment (lifetime of 8 years)<br>▪ Average the additional electricity use would be 490 kwh (per hour)<br>▪ Processing plants outsource the freezing and storing technology. The costs for freezing and storing for two weeks at -20c costs are €0.03 per kg. There are also costs for loading and discharging and the transport to and from the specialist (the cost for charge and discharge is most likely to be €2.5 (20 pallets), transport costs €250 per ride (20 pallets) and the waiting costs are €15 per pallet) |

### A4.2.4 S4 - Hot water treatment

Both steam and hot water treatments reduce numbers of *Campylobacter* by 1.5-2 $\log_{10}$ cycles, but *Campylobacter* within the muscle would not be inactivated. The appearance of carcasses treated by either method is changed to some extent, most important is the tendency for the skin to shrink and become more fragile, and for any exposed muscle to change colour slightly, In addition, the carcasses stiffen up, making 'trussing' more difficult. However, the appearance of portions prepared after treatment of carcasses is almost unaffected.

For this control, the broiler meat is subject to treatment with hot water after slaughter. It might be applied either as (a) mandatory application of hot water or more likely (b) selective application of hot water on a batch basis based on results of test T1. Another option is the application of steam to the carcass at atmospheric pressure for 24 seconds at 90°C (Whyte et al., 2003[27]).

**Table A4.1 Option S4 - Hot water**

| | |
|---|---|
| **Baseline (current status)** | ▪ Not currently applied in commercial context in EU. |
| **Impact on prevalence & evidence thereof** | ▪ Hot water treatment of carcasses (80 °C for 20 sec) would result in a public health risk reduction between 50% and 90% if applied on a non-selective basis (source: EFSA control options paper).<br>▪ Effects of hot water treatment are assumed to be uniform in all Member States.<br>▪ Application on selective basis will reduce total risk reduction because of potential for flock to turn positive between test and slaughter |
| **Costs** | ▪ Capital and operating costs. Currently being researched. |

[27] Whyte, P., McGill, K. and Collins, J. D. (2003). "An assessment of steam pasteurization and hot water immersion treatments for the microbiological decontamination of broiler carcasses. Food Microbiology 20(1): 111-117.

### A4.2.5 S5 – UV irradiation

The control consists of broiler meat being subjected to treatment with irradiation after slaughter. It might be applied either as (a) mandatory application or more likely (b) selective application on a batch basis based on results of test T1.

Irradiation should completely eliminate *Campylobacter* from carcasses (assuming no post-process recontamination). Irradiation leaves the meat essentially unchanged in appearance and uses gamma rays from isotopes such as cobalt60, or x-rays or electrons with appropriate energy spectra. Gamma rays and x-rays are more penetrating, and could be used to treat whole carcasses, while electrons are less penetrating, and so would most easily be used on portions. An advantage of x-rays or electrons is that they can be generated using relatively inexpensive machines that can be switched on and off as required and installed in most slaughterhouses. Another advantage of irradiation is that it would inactivate *Campylobacter* within the meat as well as on the outside, and it could be used on repacked and/or frozen or chilled product. Irradiation of pre-packed product would prevent post-process recontamination[28].

A key issue to be explored is the impact on product value (revenue effects) and consumer perceptions.

**Table A4.1 Option S5 – UV irradiation**

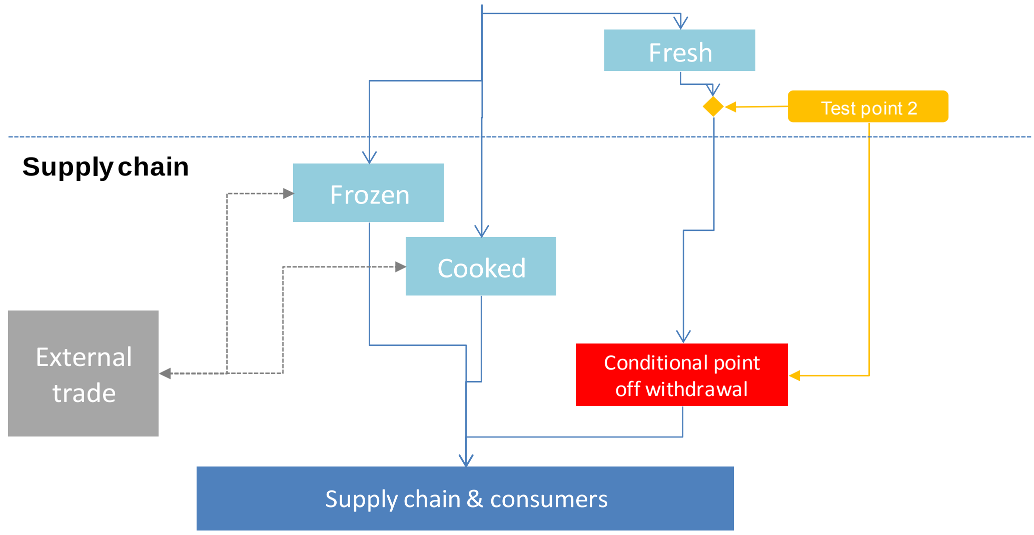
| | |
|---|---|
| **Baseline (current status)** | ▪ Not in use |
| **Impact on prevalence & evidence thereof** | ▪ 100% public health risk reduction<br>▪ Application on selective basis will reduce total risk reduction because of potential for flock to turn positive between test and slaughter |
| **Costs** | ▪ Capital and operating costs to be considered. From the literature:<br>▪ For capital investment FIPA (US Food Irradiation Processing Alliance) Q&A document reports that commercial irradiators are capital intensive; in the US, the cost to build a commercial food irradiation plant is in the range of US $3 million to $5 million, depending on its size, processing capacity, and other factors. The cost of a small-scale irradiation machinery (e.g. without accelerator and without refrigeration with small operating capacity) costs about €5-6 million. The cost of a full-fledge commercial dual accelerator with large capacity varies from €11 to 13.5 million (based on electro irradiation).<br>▪ The fee charged by the service provider is about 8-12 US cents (6 to 9 Euro cents per 0.45kg).<br>▪ Assuming a maximum of 20 pallets per lorry, with 975 kg of meat per pallet (plus 25 kg for the pallet itself), the cost of charging/discharging = €2.5/pallet, transportation costs = €250 for 20 pallets and waiting costs = €15 per treated pallet (Mangen et al., 2005). |

## A4.3 Post-processing conditional recall

The option schedule includes one option that would have an impact beyond the processing plant, albeit triggered by testing that takes place within the plant.

The model does not currently include post testing selective recall. This is because the stakeholder consultation indicated that the results of T2 would not be available before the meat was sold but a recall system does operate successfully in Denmark.

[28] EFSA Scientific Opinion on control options.




### A4.3.1 Post-slaughter testing

Testing would be undertaken in broiler carcasses after first killing. Six randomly selected carcasses are taken from a flock for testing as a pooled sample. If about 7 flocks per day are slaughtered then samples from 6*7 carcasses are tested. Each sample is tested separately and the cost for each test is about €20-30.

**Table A4.1 Option T2 – Post-slaughter testing**

| | |
|---|---|
| **Baseline (current status)** | ▪ Currently no post-slaughter mandatory testing for *Campylobacter* in place in the EU. |
| **Impact on prevalence & evidence thereof** | ▪ No direct impact but enables tactical use of other control options for infected batches at the slaughtering and processing stage. |
| **Costs** | ▪ Cost estimated vary from €10 - €30 per pooled sample tested. Additionally about €22 for courier and €7.80 for admin task per submission |

### A4.3.2 C1 – Selective recall

This option would involve mandatory testing for *Campylobacter* of batches of broiler meat destined for the fresh meat supply chain as it leaves the processing plant. The sampling regime will be agreed but batches of broiler meat would be subject to recall on a selective basis where testing indicates that *Campylobacter* presence exceeds levels defined in food safety criteria.

**Table A4.1 Selective recall**

| | |
|---|---|
| **Baseline (current status)** | ▪ Currently no post-slaughter mandatory testing for *Campylobacter* in place in the EU.<br>▪ Such testing is undertaken in some Member States. Testing is undertaken at the appropriate time for *Salmonella.*<br>▪ No testing required for frozen meat or that destined for cooked product on the basis that residual risk is negligible. |

| | |
|---|---|
| **Impact on prevalence & evidence thereof** | ▪ Helps to reduce residual risk left in (a) meat that has not been subject to decontamination (b) meat that has been subject to hot water or chemical decontaminated but remained infected.<br>▪ Impact on public health risk reduction to be agreed |
| **Costs** | ▪ The cost for testing is estimated at €10 - €30 per pooled sample tested but this is not the main cost element. By the time the test results are received the meat will be on the market. Recall will increase the cost greatly. This can be estimated at 5-10 times the market price of a chicken but has not been modelled in this study due to the high levels of *Campylobacter* in many MS. |

# Annex 5 Efficacy of control measures

**Table A5.1 Efficacy (reduction in relative risk) of on-farm measures**

| Intervention measure | Efficacy for *Campylobacter* reduction at the point of application (range in %)* | Estimated risk reduction against *Campylobacter* (if expressed in a different measure than %) | Explanation | Notes |
|---|---|---|---|---|
| Hygiene/biosecurity at 21 days**<br>[not tested in model] | 7.7 – 20 | | EFSA (2011; 2105): Table 2 p. 44 | Effect on BFP is identical to assessed effect on human health risk (% reduction in # of cases). This result is valid only for the UK (C4 ) p.119-120, EFSA (2011; 2105) |
| Hygiene/biosecurity at 28 days**<br>[not tested in model] | 12 – 32 | | EFSA (2011; 2105): Table 2 p. 44 | Effect on BFP is identical to assessed effect on human health risk (% reduction in # of cases). This result is valid only for the UK (C4 ) p.119-120, EFSA (2011; 2105) |
| Hygiene/biosecurity at 42 days**<br>[tested in model] | 38.5 - 70.8 | | EFSA (2011; 2105): Table 2 p. 44 | Effect on BFP is identical to assessed effect on human health risk (% reduction in # of cases). This result is valid only for the UK (C4 ) p.119-120, EFSA (2011; 2105) |
| No thinning (Indoor flocks) | | 1.74 | EFSA (2010) | |
| Reducing slaughter age for 10 days | | 1.98 per 10 days 50 (max) | EFSA (2001; 2105) | Have modelled 7 day reduction in slaughter age and used a range of 10-25% |
| Vaccination | 70 80 | 2log10 reduction | Reducing the numbers of *Campylobacter* in the intestines at slaughter by 3 log10 units would reduce the public health risk by at least 90% and on the carcasses by 1 log10 unit would reduce the public health risk between 50 and 90%. | This intervention is not modelled in EFSA (2011; 2105). See section 5.2.2.5.: 1,2,3,6 log reductions would yield at least 48%, 76%, 90%, 100% reduction in human cases. |
| Bacteriocins | 90 99 | 5.1 log10 to 5.9 log10 | Reducing the numbers of *Campylobacter* in the intestines at slaughter by 3 log10 units would reduce the public health risk by at least 90% and on the carcasses by 1 log10 unit would reduce the public health risk | This intervention is not modelled in EFSA (2011; 2105). See section 5.2.2.5. 1,2,3,6 log reductions would yield at least 48%, 76%, 90%, 100% reduction in human cases. |

| Intervention measure | Efficacy for *Campylobacter* reduction at the point of application (range in %)* | Estimated risk reduction against *Campylobacter* (if expressed in a different measure than %) | Explanation | Notes |
| --- | --- | --- | --- | --- |
| | | | between 50 and 90%. | |

*Source: EFSA Journal 2011; 9(4): 2105*

** Hygiene/biosecurity, no thinning and reduction in slaughter age have linear reduction effects in human cases (e.g.7.7-20% reduction Campylobacter reduction at the point of application in hygiene/biosecurity measure have also 7.7-20% reduction in human cases)*

*The linear reduction is not the case for the measures vaccination and bacteriocins which are not modelled in EFSA report (2011). In these cases the effects are not specific and the arguments are based not on experimental testing but literature review.*

*** The model is based on UK data only hence it is difficult to apply the reduction figures for other EU MS due to great variations in hygiene/biosecurity infrastructures.*

**Table A5.2 Efficacy of measures in slaughtering and processing**

| Intervention measure | Reduction concentration of *Campylobacter* in poultry meat (range in %)* | | Estimated risk reduction against *Campylobacter* (if expressed in a different measure than %) | Explanation | Notes |
|---|---|---|---|---|---|
| Chemical decontamination - lactic acid (2%) | 37 | 56 | 0.47 log10<br>0.74 log10 | | Data from table 8, p. 61 in EFSA 2011:2105. |
| Chemical decontamination - acidified sodium chlorite (1200 mg/l) | 75 | 96 | 1.26 - 1.75 log10<br>1.75 log10<br>0.5 log10<br>0.5 - 1 log10 | | Data from table 8, p. 61 in EFSA 2011:2105. |
| Chemical decontamination - chlorine dioxide (50-100 mg/l) | | | 0.49 log10<br>0.99 - 1.21 log10 | | This is not modelled in EFSA 2011:2105. |
| Chemical decontamination - trisodium phosphate (10-12% pH 12) | 67 | 84 | 1.03 log10<br>1.2 log10<br>0.5 log10 | | Data from table 8, p. 61 in EFSA 2011:2105. |
| Chemical decontamination - acidified electrolysed oxidising water (immersion) | | | 1.07 log10 | | This is not modelled in EFSA 2011:2105. |
| Chemical decontamination - peracetic (peroxyacetic) acid | 43 | | | | This is not modelled in EFSA 2011:2105. |
| Freezing (2-3 days) | 62 | 93 | 0.91 - 1.44 log10 | Reducing the numbers of *Campylobacter* in the intestines at slaughter by 3 log10 units would reduce the public health risk by at least 90% and on the carcasses by 1 log10 unit would reduce the public health risk between 50 and 90% | Table 8, p. 61 in EFSA 2011:2105. |
| Freezing (3 weeks) | 87 | 98 | 1.77 - 2.18 log10 | Reducing the numbers of *Campylobacter* in the intestines at slaughter by 3 log10 units would reduce the public health risk by at least 90% and on the carcasses by 1 log10 unit would reduce the public | Table 8, p. 61 in EFSA 2011:2105 |

| Intervention measure | Reduction concentration of *Campylobacter* in poultry meat (range in %)* | Estimated risk reduction against *Campylobacter* (if expressed in a different measure than %) | Explanation | Notes |
|---|---|---|---|---|
| | | | health risk between 50 and 90% | |
| Hot water immersion | 75 89 | 1.25 log10 | Reducing the numbers of *Campylobacter* in the intestines at slaughter by 3 log10 units would reduce the public health risk by at least 90% and on the carcasses by 1 log10 unit would reduce the public health risk between 50 and 90% | Table 8, p. 61 in EFSA 2011:2105 |
| Irradiation | 100 | 6 log10 | Reducing the numbers of *Campylobacter* in the intestines at slaughter by 3 log10 units would reduce the public health risk by at least 90% and on the carcasses by 1 log10 unit would reduce the public health risk between 50 and 90% | |

*Source: EFSA Journal 2011; 9(4): 2105*

** The link between estimated risk reduction and reduction concentration of Campylobacter in poultry meat is complex. The former also equals to the reduction of Campylobacter in human cases.*

*All intervention measures are modelled in the EFSA report except Chemical decontamination - chlorine dioxide (50-100 mg/l), Chemical decontamination - acidified electrolysed oxidising water (immersion), Chemical decontamination - peracetic (peroxyacetic) acid, which are based on literature review.*

# Annex 6 Model

As part of this project a user friendly modelling tool has been developed, both for analysis of the controls as reported in sections 6 and 9 but also as a tool for future use by policymakers beyond this project. This model displays to the user the estimated costs and benefits of applying chosen control methods at EU or MS level and will also calculate which combination of control measures is likely to produce the most cost-effective combination of controls to deliver a given reduction in *Campylobacter* incidence. We recognise that there are multiple criteria on which such decisions need to be based, for example the practicality of implementing/enforcing controls or the wider industry and consumer impacts. As such this tool should be used for the purpose for which it is intended, an aid to decision making, rather than as a policy tool per se.

This section provides an outline of the design and structure, model parameters and how data is used to provide the most cost-effective combinations of options to deliver a given level of control. Further discussion of the model parameters is found below, but it should be emphasised that this is a tool where all input data can be modified by the user so where improved data becomes available the tool can be used again to provide enhanced outputs.

## A6.1 Model design and structure

The model is spreadsheet based and requires Microsoft Excel 2003 or later. The majority of the model workings are contained as formulae in cells, but the model also uses a small quantity of Visual Basic for Applications (VBA) code to provide some of the more advanced functionality.

The model consists of a number of worksheets, containing user interfaces, calculations steps and input data. There is also an instructions sheet that documents the tool and provides easy to follow instructions for its use.

There are two main functionalities of the tool:

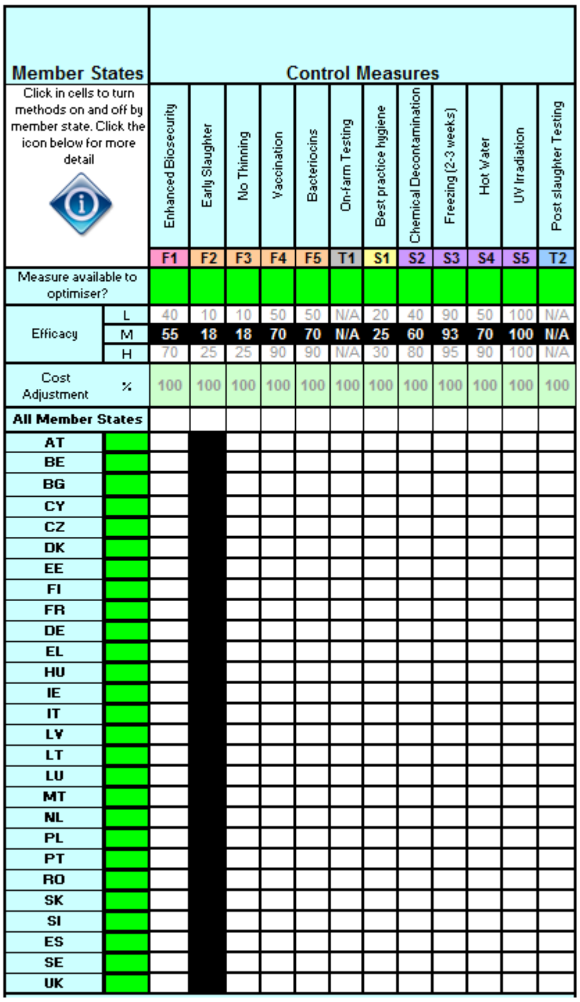
1. *Assessing the costs and benefits of a given combination of control measures*

On the main screen of the tool there is a clickable grid that allows control measures to be turned on or off by MS, and also allows MS to be included or excluded from the analysis. In line with the findings of the project, the tool enforces restrictions on which control measures can be used in combination with each other i.e. are mutually exclusive.

Having selected a combination of measures, the tool then displays the headlines figures of its estimated *Campylobacter* incidence reduction, the estimated total cost of the measures applied and the cost per DALY saved. The more detailed model outputs are described in the respective section below.

Figure A6.1 shows an example of how control measures can be turned on or off (black square indicates on) for each Member State, and where Member States can be excluded from the analysis. The colour coding of control measures shows groups of mutually exclusive methods i.e. only one from each of the groups can be picked. The controls above the main grid allow the efficacy of a measure to be adjusted between low, medium and high values, and the cost to be adjusted by a percentage if required.

**Figure A6.1 Selecting control measures**



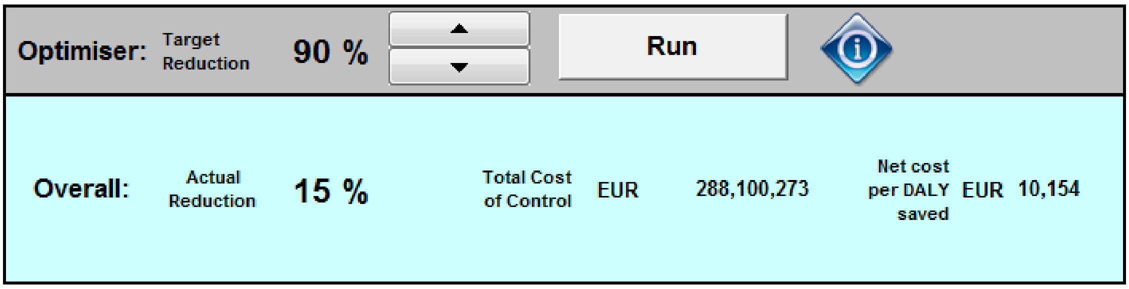
| Member States | F1 | F2 | F3 | F4 | F5 | T1 | S1 | S2 | S3 | S4 | S5 | T2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Click in cells to turn methods on and off by member state. Click the icon below for more detail | Enhanced Biosecurity | Early Slaughter | No Thinning | Vaccination | Bacteriocins | On-farm Testing | Best practice hygiene | Chemical Decontamination | Freezing (2-3 weeks) | Hot Water | UV Irradiation | Post slaughter Testing |
| Measure available to optimiser? | | | | | | | | | | | | |
| Efficacy L | 40 | 10 | 10 | 50 | 50 | N/A | 20 | 40 | 90 | 50 | 100 | N/A |
| Efficacy M | 55 | 18 | 18 | 70 | 70 | N/A | 25 | 60 | 93 | 70 | 100 | N/A |
| Efficacy H | 70 | 25 | 25 | 90 | 90 | N/A | 30 | 80 | 95 | 90 | 100 | N/A |
| Cost Adjustment % | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| All Member States | | | | | | | | | | | | |
| AT | | | | | | | | | | | | |
| BE | | | | | | | | | | | | |
| BG | | | | | | | | | | | | |
| CY | | | | | | | | | | | | |
| CZ | | | | | | | | | | | | |
| DK | | | | | | | | | | | | |
| EE | | | | | | | | | | | | |
| FI | | | | | | | | | | | | |
| FR | | | | | | | | | | | | |
| DE | | | | | | | | | | | | |
| EL | | | | | | | | | | | | |
| HU | | | | | | | | | | | | |
| IE | | | | | | | | | | | | |
| IT | | | | | | | | | | | | |
| LV | | | | | | | | | | | | |
| LT | | | | | | | | | | | | |
| LU | | | | | | | | | | | | |
| MT | | | | | | | | | | | | |
| NL | | | | | | | | | | | | |
| PL | | | | | | | | | | | | |
| PT | | | | | | | | | | | | |
| RO | | | | | | | | | | | | |
| SK | | | | | | | | | | | | |
| SI | | | | | | | | | | | | |
| ES | | | | | | | | | | | | |
| SE | | | | | | | | | | | | |
| UK | | | | | | | | | | | | |

2. *Selecting the lowest cost combination of measures which deliver a desired reduction in incidence.*

This part of the tool (henceforth referred to as the optimiser) allows a user to select a target percentage reduction in *Campylobacter* incidence in poultry meat. Having selected this target and pressing a “Run” button the tool tests all possible allowed combinations of control measures (taking approx. 10 seconds) and then displays to the user the combination of control measures which provides at least this level of reduction at the lowest cost.

Figure A6.2 below shows the interface to this part of the tool.

**Figure A6.2 Selection of controls to meet a target**




The chosen combination of measures is shown on the clickable grid referred to earlier, and once again the headline figures of the estimated actual reduction achieved, the total cost and the cost per DALY saved are displayed.

## A6.2 Model parameters

The tool relies on a large quantity of data to drive the calculations. This data was collected in the project through a variety of sources, including literature, stakeholder consultation and where necessary the judgement of industry experts.

These input parameters are spread across a number of separate worksheets, with one for each control strategy and one containing the industry structure data. All the input parameters can be modified by the user if more detailed or improved data becomes available.

### A6.2.1 Industry Structure

The industry structure sheet contains data by Member State for the following factors:

- Birds at farm
- Number of processing/slaughter plants
- Wage rates (minimum, agricultural and managerial)
- Industrial water and electricity costs
- Baseline *Campylobacter* incidence in poultry meat
- Average liveweight (kg)

These industry factors affect how the costs of measure implementation vary by MS.

### A6.2.2 Control Measure Sheets

Each control measure has a worksheet setting out its costs and effects. These are labelled with the measure code (e.g. F1 for the first farm measure, S3 for the third slaughter measure). These sheets each contain a description of the measure, its estimated effect on the *Campylobacter* incidence (with justification), cost factors for the measure, baseline and maximum uptakes by MS of the measure and finally a table setting out how the costs of each factor and overall costs of implementing the measure vary by MS. All this data comes from the research elements in the rest of the project. An example of a control measure sheet is shown in Figure 5.3 below.

## Figure A6.1 Detailed parameters for controls

| Control Measure: | Freezing | |
|---|---|---|
| Definition: | 2-3 weeks freezing | |
| Stage: | | |
| Reduction in Campylobacter Incidence (%): | 92.5 | Freezing for 3 weeks 1.77 - 2.18 log10 reduction (Sandberg et al., 2005; Georgsson et al., 2006a) |

| General Factors | | | | | | | |
|---|---|---|---|---|---|---|---|
| Cost Name | Cost of Freezing | Cost of Transport | | | | | |
| Units | EUR / kg (Deadweight) | EUR / kg (Deadweight) | EUR | EUR | EUR | EUR | |
| Type | Other | Other | | | | | |
| Lifetime (Capital Only) | | | | | | | |
| Cost | 0.03 | 0.02 | | | | | |
| Annual Cost | 0.03 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | |
| Source | From stakeholders | 15 euro per pallet of 975 kg deadweight | | | | | |

| Country Specific | Baseline Uptake | Maximum Uptake | Source | EUR | EUR | EUR | EUR | EUR | EUR | Total Cost (EUR k) |
|---|---|---|---|---|---|---|---|---|---|---|
| AT | 0 | 100 | | 598161 | 299080 | 0 | 0 | 0 | 0 | 897 |
| BE | 0 | 100 | | 983728 | 491864 | 0 | 0 | 0 | 0 | 1476 |
| BG | 0 | 100 | | 343144 | 171572 | 0 | 0 | 0 | 0 | 515 |
| CY | 0 | 100 | | 131251 | 65626 | 0 | 0 | 0 | 0 | 197 |
| CZ | 0 | 100 | | 2018902 | 1009451 | 0 | 0 | 0 | 0 | 3028 |
| DK | [illegible] | [illegible] | | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

The cost factors are the cost of implementing a control measure, expressed in a choice of units such as per 1,000 head bird or per slaughter plant and so relate back to the industry structure data provided. To give an example a particular element of a measure may cost €10 per 1000 birds processed, and another element may cost €10 000 per slaughter plant. Cost factors which are a capital cost also require a lifetime of the capital, and these costs are amortised over their lifetime using a discount rate of 4%.

The baseline and maximum uptakes are expressed as percentages. The baseline uptake represents the extent to which a measure is already being deployed in a MS. Clearly if a measure is already being used then the additional benefits of its implementation are reduced. The maximum uptakes percentage reflects the maximum extent that a measure could or would be implemented if it was mandated. This can be less than 100% to allow for a proportion of the industry to which it would not be applicable (e.g. for farm level measures some are not applicable to outdoor birds) or a proportion of the industry it is judged would not undertake the measure.

The bottom half of each control measure sheet breaks down the actual cost of implementation in each Member State by cost factor and so allow the user to see how the total costs vary by MS, and in detail how the constituent factors vary.

When costing the measures a number of assumptions have been made regarding a typical farm or slaughter plant. The measures are costed as if all farms or slaughter plants are the same, although in the real world there will be a spread of sizes and processes. It is hoped that the costings represent the average in a MS, and so provide a guide to the total costs of implementation across the whole MS, and so should not be used to represent the costs of applying a measure to a single farm or slaughter plant.

### A6.2.3 Calculations

Ultimately the data and cost calculations is pulled through into a calculations sheet, where clearly laid out step by step calculations bring together the impact of whichever combination of methods are selected in order to calculate the total estimated costs and impacts.

The reductions in *Campylobacter* incidence resulting from multiple methods are assumed to be multiplicative, i.e. if there were 100 infected birds and two measures, each of which reduced incidence by 10% then the first measure would take 10% from the 100, but the second measure would take 10% from the result of this, leading to a new infected total of 81 and a combined reduction of 19%, rather than the 20% that would have occurred if they had been considered in an additive manner.

The model considers a testing stage, labelled as T1. This is a testing of carcasses to determine *Campylobacter* infection between the farm and slaughter stages. This testing has an associated cost, but if it is applied then it is assumed that those slaughter stage methods applied directly to the carcass (e.g. freezing, irradiation) will only be applied to those carcasses found to be infected. Where these methods are costed per bird, including this testing stage can then lead to the costs of implementing these measures being reduced as they are applied to less birds.

## A6.3 Model outputs

As discussed above, for a given combination of control measures, the model displays the headline figures of calculated costs, percentage reduction in *Campylobacter* incidence and calculated cost per DALY saved. When using the optimiser the tool also displays the combination of control measures it has selected.

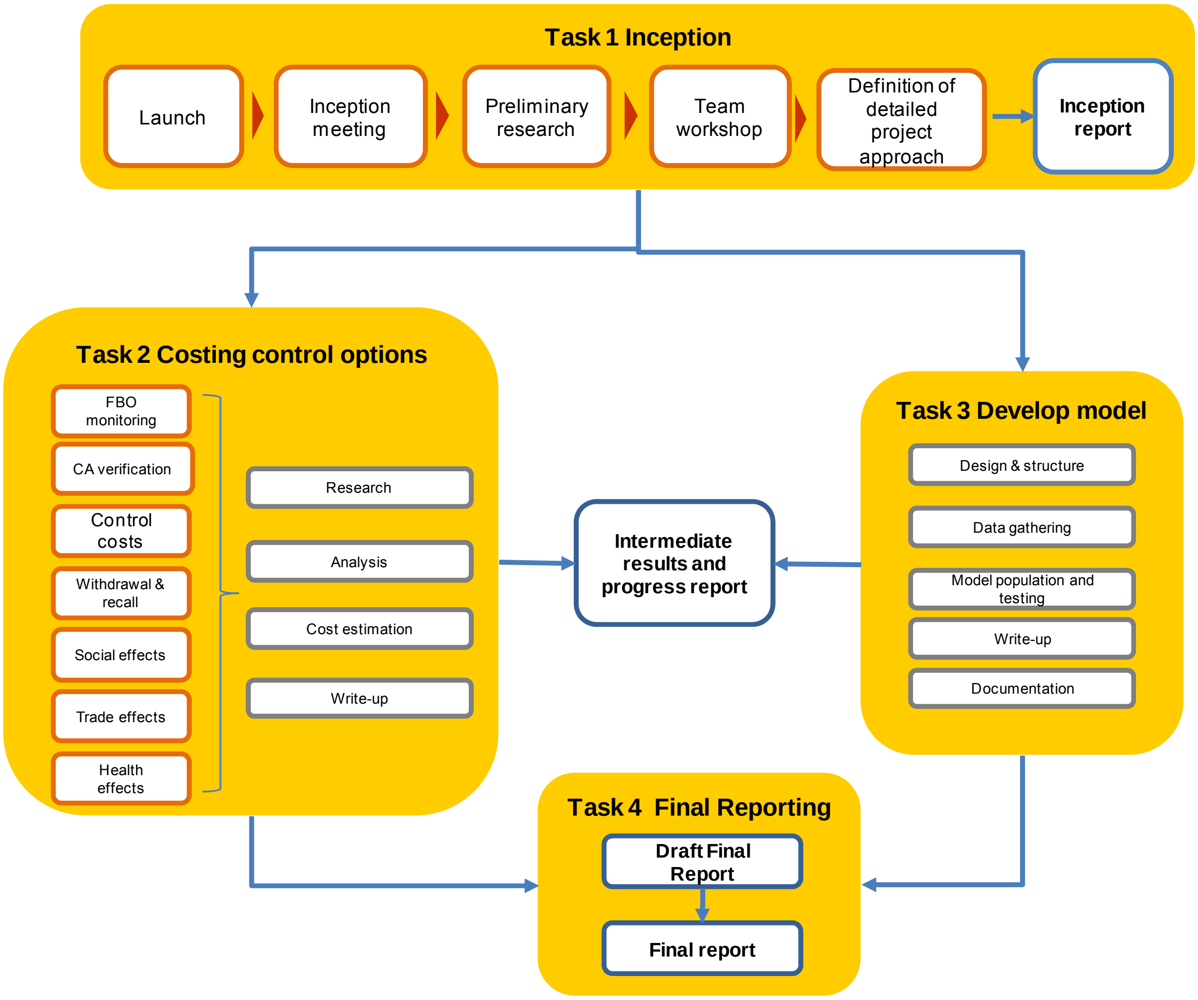
In addition to these, more detailed figures are displayed in table form on the main worksheet. These tables show the costs of each measure implemented by MS, and the percentage reduction of incidence it was estimated to achieve. It also shows the total costs and reduction at each stage i.e. farm, slaughter and overall.

A second table shows the baseline number of human cases of *Campylobacter* by MS, and the expected change in this following the control measures (this takes into account an assumption that only 30% of human cases are directly related to the handling and consuming of infected meat). Given the change in number of human cases the tool also displays this as a benefit in terms of Disability Adjusted Life Years (DALYs) saved. This calculation that breaks this down into DALYs saved per MS does not take into account the flows of poultry between MS, and instead assumes that poultry farmed in one MS are also consumed there. Finally this table shows the total cost per DALY saved, both by individual MS and for the EU as a whole.

# Annex 7 Method

This section provides a task-by-task explanation of how the project was designed and delivered. The project workflow is shown in Figure A7.1.

**Figure A7.1 Project workflow**




## A7.2 Task 1 Inception

This report marks the completion of the inception task.

## A7.3 Task 2 Costing control options

**Objective:** **To estimate cost of the key control options and their combinations**

**Deliverable:** **Cost estimates, contribution to final report**

A core set of sub-tasks will be followed for each component of the analysis (from FBO monitoring costs to health effects).

The starting point is the determination of the set of control strategies (defined from the schedule of interventions and information on their efficacy).

***Research***

A consolidated set of data requirements will be prepared and allocated to the research team. The research will include:

- Thorough analysis of the academic literature;
- A scan for other relevant studies, e.g. government reports;
- Contact with a limited number of competent authorities;
- Contact businesses and business representative organisations  (e.g. AVEC);
- Interrogation of public datasets (e.g. Eurostat).

Table A7.1 shows the data requirements and target sources.

**Table A7.1 Data requirements**

| | Supplementary data required |
|---|---|
| F1 | ▪ Cost per house or per site of providing facilities for good bio-security, based on initial capital expenditure and consumables.<br>▪ Cost of training to ensure full implementation.<br>▪ Estimate of benefits in bird performance and growth rates. |
| F2 | ▪ Cost of terminal clean-out procedures.<br>▪ Data on impacts of changing slaughter age on stocking rates, flock performance, mortality etc. |
| F3 | ▪ Data on impacts on growing regimes and product marketing.<br>▪ Possible savings on equipment cleaning. |
| S1 | ▪ Cost of specified actions need to achieve advanced hygiene levels at slaughterhouses; |
| S2 | ▪ All inclusive cost per bird or per standard batch of chemical decontamination process, inclusive of time and materials.<br>▪ Estimates of impact on product value? |
| S3 | ▪ Costs per bird or per batch of freezing on an all-inclusive basis or broken down into capital and operating expenditure requirement.<br>▪ Costs of CA inspection/verification. |
| S4 | ▪ Costs per bird or per batch of hot water decontamination on an all-inclusive basis or broken down into capital and operating expenditure requirements<br>▪ Costs of CA inspection/verification. |
| S5 | ▪ Costs per bird or per batch of irradiation on an all-inclusive basis or broken down into capital and operating expenditure requirements<br>▪ Costs of CA inspection/verification. |
| C1 | ▪ Data on scale/cost of batch recalls of broiler meat product from [?]Denmark |
| T1 | ▪ External cost to producer per batch for on-farm *Campylobacter* testing, incremental to any Salmonella tests conducted at the same time.<br>▪ Estimated time / other costs incurred by producers per batch for on-farm *Campylobacter* testing, as incremental to any Salmonella tests conducted at the same time. |

| | Supplementary data required |
|---|---|
| | ▪ Estimated time / other costs incurred by slaughterhouses in process test results, as incremental to any Salmonella tests conducted at the same time. |
| T2 | ▪ External cost to producer per batch for post-slaughter *Campylobacter* testing, incremental to any Salmonella tests conducted at the same time.<br>▪ Estimated time / other costs incurred by producers per batch for on-farm *Campylobacter* testing, as incremental to any Salmonella tests conducted at the same time.<br>▪ Estimated time / other costs incurred by slaughterhouses in process test results, as incremental to any Salmonella tests conducted at the same time. |

▪

***Analysis***

The results will be analysed, any gaps identified and strategies developed for the extrapolation of data points across the tables needed for the costing exercise.

***Cost estimation/ modelling***

A model for the costing exercise will be constructed. It will be populated with data gathers in the preceding sub-tasks and the costing estimates generated for the agreed schedule of control strategies.

***Write-up***

The results of the analysis will be written up for inclusion in the draft final report.

### A7.3.2 Interim report:

An interim report will be submitted within 3 months of contract signature, in accordance with the guidance in the project specification.

## A7.4 Task 3 Develop model

***Design and structure***

Following on from inception phase discussions and the agreed content and outputs of the model an outline design of the model will be prepared. This will define structure and content, including data requirements.

A skeleton structure will be built using MS Excel or MS Access as appropriate.

***Data gathering***

The data required for the model will be assembled, drawing on the work conducted for Task 2 and other sources as appropriate.

***Model population and testing***

The data will be loaded into the model and the model tested for coherence and reliability.

***Write-up***

A description of the model will be prepared for inclusion in the final report.

***Documentation***

The model will be documented, with a written explanation (in English) of how it is structured, the content and how to use it.

## A7.5 Task 4 Final reporting

| | |
|---|---|
| **Objective:** | **To provide clear summary of the results of the assignment** |
| **Deliverable:** | **Draft final report, final report plus executive summary** |

The structure and outline content of the draft final report (DFR) will be discussed at the time of the progress report. A DFR will be supplied within 5 months of contract signature together with the model and associated documentation.