Foodborne Pathogen: the case of *Campylobacter* in Poultry

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Foodborne illness

• Illness caused by the consumption of contaminated food
  – Pathogenic bacteria, viruses, parasites
  – Chemical or natural toxins
    • Poisonous mushrooms

• Foodborne illness usually arises from improper handling, preparation, undercooking or food storage
Foodborne illness

• It is estimated that each year in the UK:
  • around a million people suffer a foodborne illness
  • around 20,000 people receive hospital treatment due to foodborne illness
  • there are around 500 deaths caused by foodborne illness
  • it costs nearly £1.5 billion
Symptoms

- Common symptoms foodborne illnesses include
  - Vomiting
  - Diarrhoea
  - Abdominal pain
  - Fever
  - Chills
- Symptoms can range from mild to serious and can last from a few hours to several days
- Most infections are self-limiting
Long term complications

• Occasionally long term health issues can arise
  – Dehydration
  – Hemolytic uremic syndrome
  – Reactive arthritis
  – Irritable bowel syndrome
  – Guillain-Barré syndrome
Foodborne illness

Data is for England and Wales and is taken from the Public Health England Website.
**Campylobacter as a pathogen in the UK**

- Important to study in its own right
- Good model for study of environmental and management influences in animal production
- ~75000 confirmed cases annually in UK
- 1 confirmed case = 9 in the community
- ~ 3 cases every 2 minutes
- 1% of EU population
- Found in most animals
- Vehicles include:
  - Water
  - Environment
  - Raw milk
  - Pets with diarrhoea
  - Chicken

![Confirmed cases in England and Wales](image-url)
Campylobacter
Our great and glorious future outside Europe
BORIS’S CHALLENGE TO CAMERON

DEADLY CHICKEN COVER-UP
Six in ten supermarket birds have lethal bug but watchdog won’t say which stores

FOOD watchdogs have been accused of a cover-up after it emerged six in ten supermarket chickens carry a dangerous bug.

By Sean Poulter Consumer Affairs Editor

The contamination is diving a food poisoning epidemic that kills 100 people a year. Unsanitary conditions allow the bug, campylobacter, which causeschie.

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Susan Gallop: Lord Renard left her weeping

The figures were published yesterday by the Food Standards Agency. But it refuses to name the stores involved, following lobbying from retailers and Whips.

Consumer groups and academics say the FSA and the Government are more concerned with the commercial interests of the industry than public health. The FSA and producers and the FDA have
Campylobacter infection is not trivial

- WHO has named *Campylobacter* as the No. 1 food borne pathogen
- Thought not to grow in food but has a low infectious dose (~100 cells)
- More heat-resistant than previously thought
- Long incubation period of 3-10 days
- High temperature, abdominal pain and diarrhoea, which is often bloody, particularly in children
- ~1% of cases have long-term side effects, which include reactive arthritis and auto-immune diseases
- **Elderly people more at risk** and most of the deaths occur in such people with bowel cancer
- Chicken is the most important vehicle

An ulcerated colon
Figure 2: Prevalence of *Campylobacter*-colonized broiler batches in the EU, 2008 (EFSA, 2010a)
Chicken Commensal or Pathogen?

• Long history of being called a commensal
  – Thought not to impact on bird health or welfare
  – In the majority of birds at high numbers
  – No visible signs of disease

• But increasing evidence to suggest its not the harmless commensal its been thought as.....
Chickens have changed in the last 50 years

Global chicken production will need to quadruple to satisfy demand
Campylobacter and chicken: two health threats

• High level surface contamination (up to $10^9$):
  A cross-contamination risk
• Contamination of liver and muscle tissues:
  Heightened risk from under-cooking
• ~60% of cases chicken-related
• Many chicken liver paté outbreaks
• Damage to the broiler gut by *Campylobacter* facilitates its spread to tissues
Extra-Intestinal Spread

The Telegraph

Chicken liver pâté causing hundreds to fall ill
The fashion to serve just-cooked liver pâté is causing hundreds of people to fall ill with food poisoning every year, public health officials warn today.

Express

FOOD

Trend for eating chicken livers 'pink' could put lives at risk, says report
A NEW "foodie" trend for increasingly rare chicken livers is putting diners at risk of food poisoning, warns a new report.

Mail Online

Why chicken liver pate could be the most dangerous dinner party dish: Rates of food poisoning soar due to 'undercooking' trend
By Sean Poulter for the Daily Mail
In some broilers *C. jejuni* M1 damages gut epithelia

Damage to gut and diarrhoea associated with dysregulation of inflammatory responses

Humphrey et al. 2014
Chickens given *C. jejuni* get diarrhoea

**FIG. 1.** Occurrence of diarrhea in chickens (*n* = 288) fed with live cells of *C. jejuni* isolated from diarrheal patients.
Distended intestines in chickens given *C. jejuni*

FIG. 3. Distended intestine, including ceca with watery fluid of experimentally infected chickens (B) as compared with that of saline-fed control (A).

Sanyal et al 1984
Damage to gut leads to spread to tissues


Sanyal et al 1984
Campylobacter have a direct impact on broiler performance although the scale depends on bacterial strains and bird type
Weight gain and health in broilers given *C. jejuni*

Ruiz-Palacios et al. 1981
Recent findings

- *Campylobacter*-negative farms (at thin) had better (P<0.01) FCRs than farms that were positive (1.666 vs 1.690)
The interaction of *Campylobacter* with broilers

- *Campylobacter* could be regarded as opportunistic pathogens in broilers, like *E. coli* or *Clostridia* or a true pathogen
- The bacteria may more easily infect animals that are compromised by poor health and/or poor welfare
- More ‘unhealthy’ birds in flocks the more easily *Campylobacter* establishes
- This may explain links with wet litter and *E. coli*
- *Campylobacter* excreted by the first infected birds more easily infect others
- Frequent culling of ‘sick’ birds may reduce risk of *Campylobacter* infection
Inflammation

• Does inflammation play a role in extra-intestinal spread?
• Would controlling inflammation help?
• Feeding additives could lead to a healthier gut?
  – Previous studies have used pre and pro-biotics, essential oils, medium chain fatty acids

• We looked at supplementing diets with short chain fatty acids
Why fish oil?

• A number of diseases prevalent in Western societies are thought to be due to an imbalance in dietary polyunsaturated fatty acids (PUFAs)
• Wild foraging chickens consuming leafy plants have far more short chain n-3 than their domestic grain fed counterparts
• Dietary short chain (C18) n-3s decrease fractures and enhance bone strength in laying hens
• n3 PUFAs can also increase intestinal barrier function and have anti-inflammatory effects
• Reducing inflammation could control *Campylobacter*
  – *Campylobacter* acts synergistically with IFN-γ to break down tight junctions between cells.
  – Causes feedback loop of inflammation, allowing high numbers of *Campylobacter* across the epithelium
• There is very little work on this area, and none on the use of n3 PUFA diets to control *Campylobacter* infection
Aim

- To determine whether feeding chickens an n-3 supplemented diet would control *Campylobacter* colonisation.
Animal experiment

- Ross broiler chickens stocked at commercial stocking density
- Reared on standard diets containing either 0, 0.5, 0.75 or 1% Salmon oil
  - with levels being reduced by half in finisher and withdrawal feed
- Infected with *Campylobacter jejuni* M1 at 21 d
  - 10 birds analysed at 7, 14, 21 d.p.i
  - Liver and caecum
  - Hock burn and pododermatitis
  - Mortality
  - Weight gain
Campylobacter numbers in the caecum 7, 14, and 21 d.p.i. Asterisks indicate significant difference.

Diets containing Salmon oil showed a reduction of 90-99% in numbers of Campylobacter. N=10 for each time point.
Results - Liver enrichments

- *Campylobacter*-positive livers 7, 14 and 21 days post-infection.
- Asterisks indicate significant difference. Increasing n3 reduces number of positive livers.

- Number of positive livers decreased with increasing n3 PUFA in diet.
Weights

**C. jejuni infected birds**

- 0%
- 0.5%
- 0.75%
- 1%

![Graph showing weight changes with varying concentrations of salmon oil in the diet for C. jejuni infected birds.]

**C. jejuni uninfected birds**

- 0%
- 0.5%
- 0.75%
- 1%

![Graph showing weight changes with varying concentrations of salmon oil in the diet for C. jejuni uninfected birds.]

Concentration of salmon oil in diet

Weight (kg)
Mortality

Percent mortality

Concentration of salmon oil in diet

- 0%
- 0.5%
- 0.75%
- 1%
Welfare implications

- Hockmarks (black) and pododermatitis (grey)
Summary of infection results

• *Campylobacter* numbers were reduced significantly in the caecum by some of the n3 PUFA diets
  – As was the frequency of *Campylobacter*-positive livers
  – Numbers of *Campylobacter* found in livers did not differ significantly between diets, although sample sizes were small with n=10 for each time point and diet.

• These data demonstrate that addition of Salmon oil to the diet appears to reduce *Campylobacter* numbers in the intestine and the number of birds carrying it in the liver.
• Final body weight also appeared to increase
  – although differences were not significant due to low numbers of birds examined.
  – Unusually, this was not accompanied by
    • an increase in mortality
    • welfare-related culls
    • hock burn and pododermatitis
  – At 1% PUFA content mortality was increased over the other PUFA diets
  – Hock burn and pododermatitis were only significantly decreased in birds receiving the diet with the lowest n3 level
• These data suggest that too great an amount of n3 PUFA in the diet may actually have an immunosuppressive effect and predispose to disease

• Large scale studies are needed

• Mechanistic studies are also needed

• Effect on the microbiota also needs investigating
What else is done?

• There is no silver bullet, a combination approach is needed
• Other dietary additives
• Biosecurity
• Processing plant interventions
• Consumer education
• Vaccination is proving difficult
Key messages on *Campylobacter* in chickens

- **IT IS NOT A HARMLESS COMMENSAL!**
  - Shown in field and laboratory data for >30 years
  - Affects bird health, welfare and performance
  - Impact depends on bacteria strain and bird type

- **A changing host-pathogen dynamic**
  - Chickens are very different from what were
  - *Campylobacter* can mutate and take up DNA from other bacteria

- Exposure is difficult to prevent and the best way forward is to improve resistance of chickens
To control *Campylobacter* in chickens it is necessary to better understand:

- Impacts of environment and production systems
- Pathogen ecology and evolution
- Host-pathogen interactions: different hosts and different strains
- Improving gut health is central to control including reducing inflammation