Quality control and safety of raw ingredients in animal feed production:
An important issue in the control of salmonella in swine

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Overview

• Introduction
  ◦ The role of animal feed in the production of safe food
  ◦ The paradoxal role of feedstuff in the dissemination of *Salmonella*...Is it really necessary to control *Salmonella*?

• Feedstuff associated hazards
  ◦ Common types of contamination
  ◦ Feedstuff as a source of *Salmonella*

• How to control *Salmonella*?
  ◦ Pre-harvest vs post harvest measures; do we really have the choice?
  ◦ Feedstuff as a means to improve control *Salmonella*
  ◦ Importance of the farm to the table approach to control *Salmonella*: A success story in Québec

• Conclusion
Introduction

iconsinmedicine.wordpress.com
The role of animal feed in the production of safe food

- Recognized worldwide
- Recent events have underlined its impact on public health, food trade and food security
  - Outbreak of Bovine spongiform Encephalopathy (BSE) in United Kingdom
  - Food crisis associated with *Salmonella*, enterohemorrhagic E.coli and other microorganisms and antimicrobial resistance
  - Newly recognized undesirable substances: melamine, dioxins, dibenzofurans and dioxin-like PCBs, GMO…
The paradox...

- Importance of microbiological hazards vs chemical hazards for public health
  - CFIA: >99% compliance for residues
  - HC: >6000 reported human salmonellosis
  - USA: >500 deaths/year
- Many countries with national *Salmonella* control programs
- Feedstuf is a significant source of contamination of herds ... and may be considered as a tool to reduce prevalence of *Salmonella* at the herd level!
Is it really necessary to control *Salmonella*?
Foodborne pathogens

- **Salmonella and Campylobacter**: the two most important pathogens responsible of food poisoning in the world

- 10,000 cases of salmonellosis reported each year in Canada (under estimated!)

- CDC report (June 2011): 10% increase in Salmonella infections over the last 15 years in USA

**Incidence of FBPs in humans in Canada and USA (/100,000 habitants per year)**

<table>
<thead>
<tr>
<th>FBP</th>
<th>Canada (2007)</th>
<th>USA (1999)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campylobacteriosis</td>
<td>35.62</td>
<td>17.3</td>
</tr>
<tr>
<td>Salmonellosis</td>
<td>26.16</td>
<td>14.8</td>
</tr>
</tbody>
</table>

In USA:
More than 1 million people become ill from Salmonella each year.
365 millions $ direct medical cost annually.

C-enternet and Foodnet
PHAC Canada Communicable Disease Report (CCDR) weekly, June 17, 2011
Salmonella in pigs in EU

Table 12: Prevalence of *Salmonella*-positive pigs production holdings\(^{(a)}\). *Salmonella* EU baseline survey, 2008\(^{(b)}\) (EFSA, 2009b).

<table>
<thead>
<tr>
<th>Member State</th>
<th>N(^{(c)})</th>
<th>Salmonella</th>
<th>S. Typhimurium</th>
<th>S. Derby</th>
<th>Salmonella other than S. Typhimurium and/or S. Derby(^{(d)})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>173</td>
<td>5.8</td>
<td>3.2-10.3</td>
<td>0</td>
<td>0.0-2.1</td>
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<tr>
<td>Belgium</td>
<td>209</td>
<td>36.4</td>
<td>30.5-43.1</td>
<td>11.0</td>
<td>7.6-15.9</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>25</td>
<td>0</td>
<td>0.0-13.5</td>
<td>11.0</td>
<td>0.0-13.5</td>
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<tr>
<td>Cyprus</td>
<td>60</td>
<td>18.3</td>
<td>13.8-26.4</td>
<td>0</td>
<td>0.0-4.6</td>
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<tr>
<td>Czech Republic</td>
<td>161</td>
<td>15.5</td>
<td>10.9-21.9</td>
<td>2.5</td>
<td>1.0-6.1</td>
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<td>Denmark</td>
<td>198</td>
<td>41.4</td>
<td>35.2-48.4</td>
<td>12.6</td>
<td>8.9-17.9</td>
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<tr>
<td>Estonia</td>
<td>28</td>
<td>3.6</td>
<td>3.6-3.6</td>
<td>0</td>
<td>0.0-0.0</td>
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<tr>
<td>Finland</td>
<td>157</td>
<td>0</td>
<td>0.0-2.1</td>
<td>0</td>
<td>0.0-2.1</td>
</tr>
<tr>
<td>France</td>
<td>186</td>
<td>38.7</td>
<td>32.2-46.0</td>
<td>3.2</td>
<td>1.5-6.9</td>
</tr>
<tr>
<td>Germany</td>
<td>155</td>
<td>20.6</td>
<td>15.2-27.8</td>
<td>3.2</td>
<td>1.4-7.3</td>
</tr>
<tr>
<td>Hungary</td>
<td>141</td>
<td>27.7</td>
<td>21.3-34.6</td>
<td>1.4</td>
<td>0.6-4.5</td>
</tr>
<tr>
<td>Ireland</td>
<td>149</td>
<td>47.7</td>
<td>42.3-53.8</td>
<td>17.4</td>
<td>13.8-22.6</td>
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<tr>
<td>Italy</td>
<td>171</td>
<td>43.9</td>
<td>35.9-51.5</td>
<td>5.8</td>
<td>3.3-10.4</td>
</tr>
<tr>
<td>Latvia</td>
<td>28</td>
<td>28.6</td>
<td>20.5-41.0</td>
<td>0</td>
<td>0.0-7.7</td>
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<tr>
<td>Lithuania</td>
<td>72</td>
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<td>7.1-12.9</td>
<td>0</td>
<td>0.0-2.4</td>
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<td>Luxembourg</td>
<td>41</td>
<td>22.0</td>
<td>22.0-22.0</td>
<td>2.4</td>
<td>2.4-2.4</td>
</tr>
<tr>
<td>Netherlands</td>
<td>212</td>
<td>55.7</td>
<td>49.4-62.2</td>
<td>8.0</td>
<td>5.2-12.4</td>
</tr>
<tr>
<td>Poland</td>
<td>178</td>
<td>9.6</td>
<td>6.1-14.8</td>
<td>1.7</td>
<td>0.6-4.8</td>
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<tr>
<td>Portugal</td>
<td>134</td>
<td>43.3</td>
<td>35.6-52.0</td>
<td>13.4</td>
<td>8.8-20.3</td>
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<tr>
<td>Slovakia</td>
<td>96</td>
<td>18.8</td>
<td>12.6-27.7</td>
<td>3.1</td>
<td>1.2-8.7</td>
</tr>
<tr>
<td>Slovenia</td>
<td>87</td>
<td>10.3</td>
<td>5.7-18.7</td>
<td>0</td>
<td>0.0-4.1</td>
</tr>
<tr>
<td>Spain</td>
<td>209</td>
<td>53.1</td>
<td>45.6-60.0</td>
<td>12.4</td>
<td>8.7-17.7</td>
</tr>
<tr>
<td>Sweden</td>
<td>150</td>
<td>0</td>
<td>0.0-2.4</td>
<td>0</td>
<td>0.0-2.4</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>191</td>
<td>44.0</td>
<td>37.8-50.9</td>
<td>9.9</td>
<td>6.7-14.8</td>
</tr>
<tr>
<td>European Union</td>
<td>3,050(^{(f)})</td>
<td>33.3</td>
<td>30.9-35.7</td>
<td>6.6</td>
<td>5.3-7.9</td>
</tr>
<tr>
<td>Norway</td>
<td>143</td>
<td>0</td>
<td>0.0-2.5</td>
<td>0</td>
<td>0.0-2.5</td>
</tr>
<tr>
<td>Switzerland</td>
<td>154</td>
<td>11.7</td>
<td>7.9-17.3</td>
<td>1.9</td>
<td>0.7-5.2</td>
</tr>
</tbody>
</table>

\(^{(a)}\) Prevalence of *Salmonella*-positive pigs production holdings. \(^{(b)}\) Salmonella EU baseline survey, 2008. \(^{(c)}\) Number of samples. \(^{(d)}\) Salmonella other than S. Typhimurium and/or S. Derby. \(^{(f)}\) Data from all EU countries.
Basic data concerning *Salmonella*

- *Salmonella* spp. are Gram-negative microorganisms that **can survive many months in manure and feedstuff**

- If nothing is done, a positive herd/feedmill can remain positive for decades!
  - Resistance to low pHs and high temperatures

- Although few *Salmonella* serotypes are species adapted, almost all the 2340 *Salmonella* serotypes **are considered pathogenic for humans**

- In animals: No clinical signs= **Healthy carriers**
  - Exception: *Salmonella Typhimurium* (DT104) in swine
Is it really necessary to control Salmonella?

• Points to consider:
  - The Mega-reg context
  - Export Markets-salmonella “free”-products necessary to maintain markets
  - Domestic clients-incidence of foodborne diseases in Canada!
  - Control measures are also beneficial for other diseases
  - More and more a herd health concern
  - Multiple possibilities of cross-contamination if all contamination sources are not controlled
The Mega-reg context

- Slaughterhouses and processing plants must have in place **HACCP** models
- They have to **respect critical limits** for the presence of *Salmonella*
  - Swine: 8%, Boilers 20%
- A significant proportion of herds are contaminated by *Salmonella*, some of them are **highly contaminated**
- It is difficult to respect the 8 or 20% when highly contaminated lots are slaughtered...
Importance of swine in the transmission of *Salmonella* to humans in Canada?
Comparison of phenotypic and genotypic profiles of *Salmonella* strains isolated in the same geographical area during the same period of time

**Phenotypic methods:**
- Serotype
- Lysotype
- Resistance to antibiotics

**Genotypic method:**
- Pulse field gel electrophoresis (PFGE)

Rheault et al., 1999, personal communication
Comparison of genetic profiles (PFGE) and antimicrobial resistance of porcine and human strains recovered within the same geographical areas during the same period of time

Results:

• **Identical *Salmonella* genetic profiles** by PFGE of pig and human strains

• FBPs antimicrobial resistance is a complex phenomenon that slowly evolve in animal populations:
  
  ◦ **It was not possible to establish** any other direct relationship between antimicrobial resistance and previous use of growth promoter (or AM use) at the farm level.

  ◦ **No short term association does not mean no association between AM use and resistance!**

  ◦ Limited value of short term studies but **an important reservoir of resistant strains**

Fig.1 *Salmonella* Typhimurium
Restriction enzyme: *XbaI*
Importance of the results...

- Prevalence is *increasing* in swine and herds in most countries.
- **Clear link** between swine and *Salmonella* in humans.
- Significant number of isolates *multiresistant* to antibiotics.
- **A farm to table approach** is a must to reduce *Salmonella*!
Feedstuff associated hazards

Special attention to *Salmonella*
## Feedstuff associated hazards

<table>
<thead>
<tr>
<th>Type of hazards</th>
<th>Substances/agents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical</td>
<td>• Dioxins, dibenzofurans, dioxin-like PCBs</td>
</tr>
<tr>
<td></td>
<td>• Mycotoxins: <em>aflatoxin B1</em>, <em>ochratoxin A</em>, <em>zearalenone</em>, fumonisin B1, <em>deoxinivalenol</em>, T-2, HT-2</td>
</tr>
<tr>
<td></td>
<td>• Heavy metals :Cadmium, Arsenic, Mercury, Lead</td>
</tr>
<tr>
<td></td>
<td>• Veterinary drugs residues</td>
</tr>
<tr>
<td></td>
<td>• Organochlorine pesticides</td>
</tr>
<tr>
<td>Microbiological</td>
<td>• Brucella (in some countries)</td>
</tr>
<tr>
<td></td>
<td>• <em>Salmonella</em></td>
</tr>
<tr>
<td></td>
<td>• Endoparasites: Echinococcus, Toxoplasma gondii, Trichinella, Cisticercus</td>
</tr>
<tr>
<td></td>
<td>• Prion (BSE)</td>
</tr>
<tr>
<td>Toxic plants</td>
<td>• Many toxic plants found in grasslands around the world</td>
</tr>
</tbody>
</table>
Prevalence and distribution of *Salmonella* in swine herds in Canada

*Few RCMS research projects...*
Why to control *Salmonella* at farm level?

- Excretion of salmonella in feces during a few days
- Then becomes silent carrier (carrier at the MLN level)
- After a stress (ex. : transportation), excretion on Salmonella and contamination of other pigs (< 4 h)

Risk of contamination of pigs during transport and lairage
Risk of contamination of carcasses during evisceration
Why to control *Salmonella* at farm level?

???

???

Excretion of salmonella in feces during a few days

Then becomes silent carrier (carrier at the MLN level)

Importance to include *feedmills in the food chain*?

**Transport**: a critical (and neglected) component in the control of *Salmonella*
Herd contamination by *Salmonella*

- Cereals
- Wildlife
- Environment
- Birds/Pets

**FEED MILLS**
- Sanitation
- Others
- Rodents
- Pigs

**FARM**
- Abattoir Processing
- Replacement Animals
- Consumer

**RENDERING PLANTS**
Feedstuff as a source of Salmonella

- Significance of *Salmonella* contamination of animal feed for public health?
  - **At the herd level**, serotypes found in finishing animals are not always those found in feedstuff (Davies and Hinton, 2000)
    - Exception: Experimental infection with *S. Anatum*
    - Data on contamination rates
  - **At the national level** many examples of the impact of feedstuff contamination
    - The *Salmonella* Agona example in USA
  - **Means to control** *Salmonella* in feedstuff
Figure 2. Persisting burden of human disease due to Salmonella enterica serotype Anata in the United States

John A. Crump,1,2 Patricia M. Griffin,1 and Frederick J. Angulo1

1Foodborne and Diarrheal Diseases Branch, Division of Bacterial and Mycotic Diseases, National Center for Infectious Diseases, and 2Epidemic Intelligence Service, Division of Applied Public Health Training, Epidemiology Program Office, Centers for Disease Control and Prevention, Atlanta, Georgia
In 1970, *S. enterica* serotype Agona emerged as a public health problem in several countries. In the United States, before 1970, *S. enterica* serotype Agona infection of humans had been reported only twice, once in 1967 and again in 1968. By 1972, 507 isolates from humans had been reported, and *S. enterica* serotype Agona had risen to be the eighth most frequently isolated *S. enterica* serotype. Human infections occurred predominantly in states with poultry-raising operations that used feed derived from Peruvian fish meal. An epidemiological investigation in Arkansas implicated chickens served at a restaurant. The chickens were traced to a farm in Mississippi that used animal feed derived from Peruvian fish meal. The Peruvian fish meal had been contaminated with *S. enterica* serotype Agona before the animals were infected [11] and was found to
## Reported *Salmonella* prevalence

<table>
<thead>
<tr>
<th>Type of feed</th>
<th>Reported prevalence</th>
<th>references</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish meal</td>
<td>0,4-12,1%</td>
<td>EFSA 2007, Hoszowski 2008</td>
</tr>
<tr>
<td>Processed animal proteins</td>
<td>0,5-56%</td>
<td>EFSA 2007, Malmqvist 1995; McChesney et al, 1995</td>
</tr>
<tr>
<td>Pelleted feed</td>
<td>4,6-25,0%</td>
<td>Jones and Richardson 2004, Smeltzer et al. 1980; 1994 FDA data reported by David and Hinton, 2000</td>
</tr>
<tr>
<td>Mash feed</td>
<td>20,5-64,0%</td>
<td>Jones and Richardson 2004, Smeltzer et al. 1980</td>
</tr>
</tbody>
</table>
Means to control *Salmonella* in feedstuff

- **Control of Pre-requisites** such as
  - Rodents
  - Sanitation
  - Bird access…

- Test regularly for **incomings**
  - Importance of sampling (size, transport,…)

- **Control of Critical Control Points (HACCP)**
  - **Factors that favor its proliferation:**
    - Humidity in addition to temperature <70°C (condensation)
  - **Factors that favor its protection:**
    - Biofilms
    - The accumulation of fats and oils
Means to control *Salmonella* in feedstuff

Control of the production process

- **Heat Treatments:**
  - Effectiveness of the treatment related to:
    - Combination of temperature, humidity and time
    - The initial microbial load of the feed
    - The thermal resistance of the *Salmonella* strain involved
  - Type of treatments:
    - Long lasting Hydrothermal treatments (Creus E. 2012)
      - E.g. ripening treatments where temperatures normally reach between 80°C and 100°C for 4-6 minutes
      - Significant reduction or almost complete elimination of microbial load
Means to control *Salmonella* in feedstuff

**Control of the production process**

- **Chemical treatments:**
  - Combination of different organic acids or mixture of salts
    - Formic acid = most effective
    - Propionic acid and lactic acid
  - Products containing aldehydes, terpenes and surfactants
  - Sterility of products not guaranteed
  - Effectiveness related to:
    - Treatment implementation,
    - Feed conditions (pH, humidity)
    - Type of contamination (microbial load)
    - Salmonella strain…

**Monitoring program for production process and finished product quality control**
Recommendations to control *Salmonella* in feed

- **Check the raw materials** for *Salmonella* and don’t let contaminated raw materials enter the feed mill
- **Keep the unclean side of the feed mill** as clean as possible
- **Efficient heat treatment** of all feed
- **Don’t only control the feed. Control the critical control points** in the production line
- **Minimize the risk** for recontamination (physical barrier)
- **Avoid condensation** and free water
How to control *Salmonella* at farm level?

[Links to farminguk.com and salmonellablog.com]
The control of Salmonella

Common contamination sources
Control strategies

Once Salmonella has contaminated a production system, efforts should be made to reduce its spread and proliferation. In most cases, eradication is very difficult!
General principles for the control of *Salmonella* in a swine herds

- Reduce sources of contamination by new strains
  - *Control most common contamination sources*
    - Biosecurity measures and others (animal feed)
  - *Avoid introduction of positive animals (particularly from highly contaminated herds)*
    - Detection of positive animal or herds

- Cut the re-contamination cycle within the barn
  - *Reduce the number of microbes by a good disinfection protocol*
  - *Biosecurity* (ex. vaccination trials …)

- **Treatment** of other diseases and *Salmonella*! (use of antibiotics-impact on normal flora)
CONTAMINATION SOURCES - RODENTS

- **Rodents** = often found *Salmonella* positive.

- Establish a good rodent control program

- **Cats** are not considered as a good control means (!).
  - recycle the *Salmonella* from the mice,
  - can contaminate the environment with *Toxoplasma*
CONTAMINATION SOURCES - TRUCKS

- Stress is inevitable during transport and lairage

- **Reduction of exposure** levels in the truck and holding pen is crucial

- Interventions to **reduce environmental contamination** in the trucks and holding pens need to be developed and tested
  - *Salmonella* often isolated from trucks
  - Same serotype found in truck and herds previously exempt of *Salmonella* (Quessy et al, 1999)
Once introduced, *Salmonella* is spread within the barn every time animals are mixed and by contaminated material.

- **Importance of basic biosecurity measures**, such as washing hands and boots to avoid spreading

- **Barns with drainage problems** are also often found positive.

- **Recontamination** by rodent, boots and even flies in highly contaminated lots!
PFGE of *S. Typhimurium* from different production lots

- Lot #1
- Lot #2
- Lot #3
- Disinfected
- Nursery

- Same genotypic profile, (PFGE) recovered from animals
- In subsequent production lots
- Hygiene practices were not properly applied (Letellier et al., 1999b)
CONTAMINATION SOURCES - FEEDSTUFF

- Traditionally considered as an important source of contamination
- Measures applied on swine farms to reduce prevalence of *Salmonella* have been based on the control of various risk factors and improvement of hygiene
- Texture and granulometry are implicated in *Salmonella* shedding reduction

**Mash feed vs pelleted feed**
A significant number of studies reported that feed formulation can influence the outcome of the infection in pigs.

**Mash feed vs pelleted feed**

<table>
<thead>
<tr>
<th>Pelleted</th>
<th>500</th>
<th>750</th>
<th>1250</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mash</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Field trials to evaluate the efficiency of mash feed to reduce *Salmonella* shedding in swine

LETELLIER A. (1), J. MÉNARD (2), S. QUESSY (1)

(1) Research Chair in Meat Safety, Faculté de médecine vétérinaire, University of Montreal, St-Hyacinthe, Quebec, Canada

(2) F. Ménard Inc. Ange-Gardien, Quebec, Canada

Proceeding Safe pork 2003. Greece
## Results

<table>
<thead>
<tr>
<th>Farm</th>
<th>Pelleted feed period</th>
<th>Mash feed period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No of collected samples</td>
<td>Percentage of positive pens</td>
</tr>
<tr>
<td>1</td>
<td>68</td>
<td>72%</td>
</tr>
<tr>
<td>2</td>
<td>63</td>
<td>46%</td>
</tr>
<tr>
<td>3</td>
<td>64</td>
<td>73%</td>
</tr>
<tr>
<td>total</td>
<td>195</td>
<td>64%</td>
</tr>
</tbody>
</table>

*A one-tailed Fisher’s exact test was used*
These results indicate that...

- Use of *mash feed* can thus be considered as an interesting measure that can be part of a comprehensive plan to control *Salmonella* in swine farms.

- Research is currently being conducted to *assess the efficiency*, in field conditions, of mash feed in older animals and to understand how the size of feed particles can affect the shedding of *Salmonella* (pH effect, LAB, fatty acids...).
CONTAMINATION SOURCES - REPLACEMENT ANIMALS

- **Replacement animals** = major contamination source in swine herds (Letellier et al., 1999b).

- **Without Salmonella surveillance program**, a high number of sources of unknown status will lead to contamination.

- Purchasing animals from herds with a **negative status** is undoubtedly a critical step in the control of *Salmonella*.
The control of Salmonella

Pre-harvest vs post harvest measures; do we really have the choice?
Risk Factors Associated with the Presence of *Salmonella* on Hog Carcasses


- There is still a need to better understand the sources of contamination and risk factors at slaughter associated with the presence of *Salmonella* on hog carcasses
- Or … How the on farm status affects directly the contamination rate of the final product

- 312 farms
- 10 federally registered slaughterhouses
- 5 provinces (Qc, Ont, Sask, Man, BC)
- 7441 carcasses
Results: Risk factors

The relationship between the status of the carcass and its serological status was demonstrated at the lot level (logistic regression model)

<table>
<thead>
<tr>
<th>Relationship</th>
<th>Between</th>
<th>Odds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive and significant</td>
<td>The percentage of seropositivity and the percentage of positive carcasses</td>
<td>The odds that a lot showed a high score of positive carcasses increased by a factor of 5 when it had a serology &gt;20%, compared with 0% (p&lt;0.0001)</td>
</tr>
</tbody>
</table>

Conclusion: On farm status affect directly the contamination rate of the final product!
All incoming stuff at farm level is a potential source of Salmonella including feed!!
PFGE indicates that, when contamination of carcasses was related to environment, most strains isolated from the carcasses came from the pre-evisceration environment.

***Importance of initial status and/or lairage area vs cross-contamination
<table>
<thead>
<tr>
<th>Products</th>
<th>Examples</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probiotics</td>
<td>Lactobacillus, yeasts, mixed flora</td>
<td>Stabilization of gut flora, competition flora, bacteriocines, immunostimulants</td>
</tr>
<tr>
<td>Prebiotics</td>
<td>Fructo-oligosaccharides</td>
<td>Promoting growth or activity of some LAB, competition, competition flora</td>
</tr>
<tr>
<td>Phages</td>
<td>Bacteria specific</td>
<td>Bacterial lysis</td>
</tr>
<tr>
<td>Acidifiants</td>
<td>Lactic, acetic, formic, propionic, butyric acids…</td>
<td>Promoting growth of LAB or directly affecting the survival of Salmonella</td>
</tr>
<tr>
<td>Vaccines</td>
<td>Live: SC-54, Slow delivery: microsphere/sub-unit</td>
<td>Stimulation of cellular / humoral immunity, both in importance to eliminate salmonella. Cellular immunity is particularly important to increase cytokine production and increase activation of pagocytes</td>
</tr>
<tr>
<td>Egg yolk IgY</td>
<td>Specific to Salmonella</td>
<td>Role in opsonization and increase phagocytosis?</td>
</tr>
</tbody>
</table>
A success story in Québec, Canada: Global *Salmonella* control in an integrated swine production system

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SAFEPORK INTERNATIONAL SYMPOSIUM
September 30th, 2009
Québec, Canada
Salmonella...

Most important risk factors:

- Environmental contamination
- Source of replacement gilts
- Mixing sources of pigs
- **Use of pelleted feed for sows and finishers**
- Lack of all-in/all-out pig flow
F. Ménard inc.

- 30,000 sows (Canada)
- Integrated company
- Farm to fork
- AIM: Limit Salmonella contamination of pork carcasses
Experimental design...

- 10 years intervention program in an integrated approach to control risk factors associated with *Salmonella* contamination in a FARM TO FORK APPROACH
Environmental sampling in swine herds positives for *Salmonella* spp

<table>
<thead>
<tr>
<th>Samples</th>
<th>Farms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Pens</td>
<td>18/18</td>
</tr>
<tr>
<td>Water</td>
<td>11/14</td>
</tr>
<tr>
<td>Feedstuff</td>
<td>2/5</td>
</tr>
<tr>
<td>Floors</td>
<td>1/3</td>
</tr>
<tr>
<td>Doors</td>
<td>2/4</td>
</tr>
<tr>
<td>Dead animals</td>
<td>12/14</td>
</tr>
<tr>
<td>Rodents (animals and traps)</td>
<td>1/4</td>
</tr>
<tr>
<td>Flies</td>
<td>6/7</td>
</tr>
<tr>
<td>Spider, cricket, grasshopper</td>
<td>0/1</td>
</tr>
<tr>
<td>Birds fecal material</td>
<td>-</td>
</tr>
<tr>
<td>Boots</td>
<td>1/2</td>
</tr>
<tr>
<td>Shovel</td>
<td>1/1</td>
</tr>
<tr>
<td>Broom</td>
<td>0/1</td>
</tr>
<tr>
<td>Ventilation</td>
<td>2/8</td>
</tr>
<tr>
<td>Dust</td>
<td>2/2</td>
</tr>
<tr>
<td>Exterior (soil near dead animals)</td>
<td>1/7</td>
</tr>
<tr>
<td>Total</td>
<td>60/91</td>
</tr>
</tbody>
</table>

Clinical sign | No Clinical sign

## Prevalence and distribution of *Salmonella* spp. in an integrated swine unit

<table>
<thead>
<tr>
<th>Production level (n)</th>
<th>No of samples</th>
<th>No of positive isolates</th>
<th>Prevalence (IC95)¹</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MULTIPLIER</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Replacement gilts (1)</td>
<td>63</td>
<td>10</td>
<td>15.9 % (8.3-27.7)</td>
</tr>
<tr>
<td>Sow (gestation) (1)</td>
<td>148</td>
<td>8</td>
<td>5.4 % (2.5-10.7)</td>
</tr>
<tr>
<td>Farrowing houses-nursery (1)</td>
<td>136</td>
<td>3</td>
<td>2.2 % (0.6-6.8)</td>
</tr>
<tr>
<td><strong>Finishing unit for gilts (6)</strong></td>
<td>183</td>
<td>40</td>
<td>21.9 % (16.2-28.7)</td>
</tr>
<tr>
<td><strong>COMMERCIAL</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farrowing houses (14)</td>
<td>656</td>
<td>37</td>
<td>5.6 % (4.1-7.8)</td>
</tr>
<tr>
<td>Nursery off-site (4)</td>
<td>192</td>
<td>2</td>
<td>1.0 % (0.2-4.1)</td>
</tr>
<tr>
<td>Finishing unit (14)</td>
<td>545</td>
<td>51</td>
<td>9.4 % (7.1-12.2)</td>
</tr>
<tr>
<td>Total samples</td>
<td>1923</td>
<td>151</td>
<td>7.9 % (6.7-9.2)</td>
</tr>
<tr>
<td>Total farms</td>
<td>41</td>
<td>29</td>
<td>70.7 % (54.3-83.4)</td>
</tr>
</tbody>
</table>

¹Confidence interval 95%
Interventions to reduce *Salmonella* in farms and on carcasses

1. Sourcing with negative replacement gilts
2. **Feed: use of mash coarse feed (***Salmonella free*) in breeding herds and gilt finishers**
3. Rigorous cleaning and disinfection procedures (farms, transport vehicles, slaughtering facilities, accessories)
4. All-in/all-out and single source pig flow
5. Early detection and control of scours
6. Fasting pre-slaughter


Salmonella monitoring program
F. Ménard inc. (1999-2008)

- Multiplication replacement gilts
  - Sero + bacterio
- Multiplication sow herds
- Commercial replacement gilts
  - Sero + bacterio
- Commercial sow herds
- Nurseries
- Finishers
  - Sero + bacterio
- Slaughterhouse – Pork Carcasses
  - Bacterio

Transport vehicles and environment
Bacterio
# Results

Sampling of **disinfected environment** previously exposed to *Salmonella* positive pigs

<table>
<thead>
<tr>
<th>Samples</th>
<th># positives / # tested</th>
<th>% positives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport vehicles</td>
<td>16/160</td>
<td>10%</td>
</tr>
<tr>
<td>Pens</td>
<td>16/180</td>
<td>9%</td>
</tr>
<tr>
<td>Unloading ramps + alley ways</td>
<td>5/14</td>
<td>36%</td>
</tr>
<tr>
<td>Water bowls</td>
<td>1/9</td>
<td>11%</td>
</tr>
<tr>
<td>Brooms</td>
<td>3/3</td>
<td>100%</td>
</tr>
<tr>
<td>Boots</td>
<td>1/2</td>
<td>50%</td>
</tr>
<tr>
<td>Feed bins</td>
<td>0/4</td>
<td>0%</td>
</tr>
<tr>
<td>Heater</td>
<td>0/1</td>
<td>0%</td>
</tr>
</tbody>
</table>

F. Ménard inc. 1999-2001
Bacteriological and serological *Salmonella* status

Replacement gilts (20 and 120 kg) (1999 to 2008)
Salmonellosis cases and *Salmonella* spp isolation in fatteners (1999 to 2008)

- **N= 657**
- **2000: 608**
- **2001: 657**
- **2002: 623**
- **2003: 599**
- **2004: 598**
- **2005: 652**
- **2006: 710**
- **2007: 722**
- **2008: 765**

% positives

- **N = Number of batch of pigs produced per year**

% positives

- **2001**: 233
- **2002**: 328
- **2003**: 425
- **2004**: 339
- **2005**: 812
- **2006**: 907
- **2007**: 606
- **2008**: 474
Conclusions
Key points for a successful control of *Salmonella*

1. Adopt a long term integrated approach
2. Manage the *Salmonella* status of replacement gilts and environment
3. Strict all-in/all-out and single source pig flow
4. Monitor status and interventions through bacteriological sampling, (including feed) and serology
5. Put in place a pre-slaughter management program
Pre-harvest vs post harvest measures; do we really have the choice?

• So far, in most developed countries, we rely mostly on post harvest control measures
  – Cheaper, targeted, efficient
    • But best ones (e.g., irradiation) are not accepted by the public
    • And some have reached their limits (chlorine) and cause growing concerns for consumers
  – Current post harvest measures can deal with «regular» contamination rates but not with exceptionnal ones
    • Salmonella 20% threshold in pig
Pre-harvest vs post harvest measures; do we really have the choice?

But swine industry should consider:

- **Surveillance programs** to identify and manage herds highly contaminated by *Salmonella* and mandatory HACCP
- **Integration of HACCP programs** through a gate to plate approach (e.g. *Salmonella at Feed mills*)
- Pay attention to missing links (e.g. raw material, animal transportation…)
- Self limitation on the use of some antimicrobial agents (e.g. amoxicillin, tetracycllin…)

Conclusion

- An effective control of *Salmonella* on pork carcasses can be achieved through integrated interventions.
- Continuous monitoring is essential to validate the program.
- There are no contradiction between pre and post harvest approaches; both are needed but we cannot always solve the problems with current post harvest measures.
Conclusion

- Control of *Salmonella* is a challenge for the entire animal production industry
- A farm to plate approach, including the animal feed industry is needed to better control *Salmonella*
  - **HACCP** is the best tool to control *Salmonella*
  - Need to harmonize feedmills HACCP to other models
- Emergence of multiresistance in *Salmonella* strains will
  - Increase concerns and testing (*Salmonella*-negative policy adoption for animal feed ?)
  - Promote use of alternatives to antimicrobial agents
Thank you for your attention!

Questions?
HACCP concept

- Identifying potential food safety problems
- Determining how and where these can be controlled or prevented
- Describing what to do and training the personnel
- Implementation and recording
HACCP principles

1. Conduct a hazard analysis
2. Determine the CCP’s
3. Establish critical limit(s)
4. Establish a monitoring system
5. Establish corrective actions
6. Establish verification procedures
7. Establish documentation
STEP in the process where a control can be applied and where a hazard can be prevented, eliminated or reduced to an acceptable level.

Examples: Mixing (time), Pelleting (T)
Prerequisite…

• Standard operation procedures, must be implemented before HACCP plan:
  - Premises (exterior – interior building)
  - Transportation and storage
  - Equipment
  - Personnel training
  - Sanitation and pest control
  - Process control and documentation
  - Recall program
  - Allergen