Flock Management to Optimize Broiler Gut Health Without Antibiotics

Rob Renema, PhD FICN
A Chain Is Only As Strong As It’s Weakest Link

- Feed Quality – Texture, Ingredients
- Ambient Conditions
- Sanitation
- Ventilation
- Biosecurity
- Pest & Rodent Control
- Gut Health
- Light Programs
- Nutrition – Formulation
- Immune Status
- Feed Space - Availability
- Stocking Density
- Steady State Feed Intake
- Chick Quality
- Litter Conditions
- Welfare
- Pathogen Challenges
- Water Space - Availability

Broiler 50 years ago  Broiler 30 years ago  Today’s Broiler
**Figure 3-1:** Global antibiotic consumption in livestock (milligrams per 10 km² pixels) 2010

Source: Van Boeckel et al. 2015
A Brief History of AGP use in Livestock

- Antimicrobial Agents first approved for use as feed additives in livestock without prescription in 1951 (US Food and Drug Administration)

- Practice of feed administration of these Antibiotic Growth Promoters (AGPs) at non-therapeutic concentrations has increased by 10- to 20-fold since the 1950s. Without intervention, could increase 10-fold by 2050.

- World Health Organization (WHO) recommends ban of non-therapeutic use of AGPs, veterinary oversight (prescription-based system) and monitoring of antimicrobial resistance in bacteria.
Deaths due to Antimicrobial Resistance (AMR)

Impact of AMR

Deaths attributable every year

O’Neill 2016 – Review on AMR
Do we need AGPs?

Use changed from growth promotion to disease prevention

Viewed as crutch for those not willing or able to focus on management conditions
- Hatchery injection of antibiotics
- Bird density
- Health challenges due to poor brooding, culling, environmental conditions etc.

How does this work in a world of variable poultry housing and feeding conditions?
- Chick Quality, disease, and management challenges?

Does global income disparity affect our ability to reduce antibiotic use in poultry diets?
Canada: Most RWA Programs in Newer Barns
What Happens when have Low-tech Facilities?

* Can’t control environment or disease vectors
* CO from in-barn combustion heating?
* Antibiotic use bans, but does use go down if keep needing to treat?
* Different standards for local vs. export market?
  * Can’t sell at EU price locally
Normal Poultry Gut Function may Predispose Birds to Diseases Originating from Hindgut Bacteria

- Digesta ‘sloshes’ within 10 cm sections to maximize absorption and minimize weight.
- May inadvertently move bacterial too far upstream
Optimal rate of digestion results in little substrate for bacteria

Starch
Fat
Protein

Fewer Bacteria

Absorbed nutrients

Bedford (2002)
Poor digestion by the bird leads to more substrate for hindgut bacteria. Starch, Fat, and Protein are processed, leading to More Bacteria and Fewer absorbed nutrients. Response is to produce more enzymes and grow a larger intestine. Costly in energy terms. Bedford (2002)
Healthy

Dysbiotic

Dysbiotic/diseased

Source: Filip van Immerseel DSM webinar 2020
2020 Poultry Nutrition & Feed Survey

Poultry health challenges after antibiotic reductions/elimination

- Coccidiosis: 52%
- Necrotic enteritis: 51%
- Colibacillosis: 40%
- Gangrenous enteritis: 11%
- Other: 13%

© 2020 WATT Global Media
2020 Poultry Nutrition & Feed Survey

Greatest challenges faced in antibiotic-free poultry production

- Inconsistent results with feed additive alternatives: 42%
- Feed additive costs: 29%
- Learning curve for nutritionists: 18%
- Difficulty implementing changes at the farm level: 27%
- Significant capital investments to improve animal welfare: 18%
- Overcoming losses related to production without antibiotic growth promoters: 29%
Data integration: resistance of Salmonella to ceftriaxone from chickens and humans and farm-level antimicrobial use data

AMU- p35 EN, p39 FR
Category II Antimicrobial Use after 2018 Ban

- **Streptogramins (Virginiamycin, Stafac)**
  - Concern that Orthosomycin (Surmax) use would increase.
  - Uncategorized antibiotic of human health importance
  - Use dropped between 2019 and 2020.
    - Improvements in flock management?

- **Marcolides (Tylan)**

Based on survey results
7-Day Mortality Trend

*Based on Alberta hatchery survey
Growth response to AGPs appears to be small in optimised production systems.

Loss of income higher in lower income countries with less developed hygiene and production practices.

### Table 6. Species-specific relative average daily growth difference between animals raised with and without antibiotics as growth promoters.

<table>
<thead>
<tr>
<th>Animal</th>
<th>1980s literature (%)</th>
<th>2000s literature (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Chickens</td>
<td>4</td>
<td>0.7</td>
</tr>
<tr>
<td>Pigs</td>
<td>9</td>
<td>1</td>
</tr>
</tbody>
</table>
What Tools do we have at Production Level?

- Value-chain vaccination programs
- Additives with antibiotic replacement qualities
  - New combinations for increased impact
- Brooding and environmental management
  - Optimize water system and flock health
- Future / emerging technologies
  - New regulations and consumer pressure may accelerate change and demand more resources into innovation
Fig. 1. Various classes of antibiotic alternatives that are available for use in poultry production.
Alternatives to AGPs: Confusion over Expectations vs. Advancement

Feed additives vs. other reasons?
- Progress through better genetics, husbandry, health practices, and biosecurity.
- Not through nutritional feed additives alone.

Opportunity for alternative to AGP technologies to continue to improve to meet ongoing challenges of the transition away from antibiotics
- Clear that understanding of host-microbiome interactions is a necessary part of this future
Identify Mechanisms of AGPs and Use This to Identify / Design AGP Replacements

Observational empirical methods that have led to variable results for many products that have the potential to work

- “feed them and weight them” studies

More recently see more work studying mechanisms involved in AGP function and working to identify alternatives that mimic physiological response to AGPs

- Do they impact the gut flora, action of the gut, or both?
- How + Why they work (or don’t!)

Animal environment (density, stress, activity level, diet, feed form) will influence both gut microbiota and the host.
Animal environment (density, stress, activity level, diet etc.) will influence both gut microbiota and the host.

- Can negate expected effect of treatment
- Good conditions may also not show protective effect

**Complicating Factor of Barn Conditions**

Inglis, AAFC Lethbridge (C.Perfringens challenge)
### Suggested causes of poor broiler uniformity

<table>
<thead>
<tr>
<th>Factor</th>
<th>Effect on uniformity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breeders with poor uniformity during rearing</td>
<td>X</td>
</tr>
<tr>
<td>Absence of pre-warming of stored eggs</td>
<td>X X</td>
</tr>
<tr>
<td>Mixing of chicks from different aged breeders</td>
<td>X X X</td>
</tr>
<tr>
<td>Poor brooding conditions</td>
<td>X X X X X</td>
</tr>
<tr>
<td>Health problems in the 1(^{st}) week</td>
<td>X X X X X X</td>
</tr>
<tr>
<td>Health problems at the end of the growing period</td>
<td>X X X X X</td>
</tr>
<tr>
<td>Nutritional values (amino acids) poorly digested raw materials</td>
<td>X X X</td>
</tr>
<tr>
<td>Insufficient ventilation, ammonia or poor air flow</td>
<td>X X X</td>
</tr>
<tr>
<td>Poor adjustment to feeding and drinking equipment</td>
<td>X X</td>
</tr>
</tbody>
</table>

*Note impact of brooding conditions and early exposure to disease on final BW uniformity of broilers (Source = Hubbard)*
Age & Feed to Produce a 2040 g Broiler

Starter period more important!
What Measures Should We Take During Brooding?

- DOA's/Mortality: 85.2%
- Subjective Assessment: 75.8%
- Weight: 56.9%
- Crop Fill: 47.2%
- Vent temperature: 16.7%
Why is early feeding important?

2 to 3 day period of transition after hatch when chick has to absorb residual yolk into both the gut and the circulatory system

Feed in gut stimulates yolk secretion to the small intestines and triggers uptake of fat soluble nutrients

Without feed in the gut, yolk utilisation is slower

- Opposite of what many assume to be true!
The Effects of Dietary Treatment on BW

<table>
<thead>
<tr>
<th></th>
<th>DAY 1</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>42.3</td>
<td>42.0</td>
<td>42.0</td>
<td>43.4</td>
<td>43.9</td>
</tr>
<tr>
<td>Control</td>
<td>b</td>
<td>b</td>
<td>b</td>
<td>a</td>
<td>a</td>
</tr>
<tr>
<td>Feed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sawdust</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gel Puck</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Uppercase letters indicate significance at P < 0.05.
Getting off to a Fast Start

Presence of ANYTHING in the gut as early as possible provides an early growth advantage.
- Liquid = transient effect; Solid = stimulates growth

Why? Accelerates gut growth and maturation of gut enzyme secretion for digestion of protein, fat, and carbohydrate
Breast Muscle Development

Early access to feed increases proliferation of satellite cells (breast muscle cell precursors) in the first 1-2 days after hatch.

Early feeding can increase breast yield by 4-10% at normal processing ages over birds that were delayed.

Even small differences help: Doubling feed on brood paper from 25 to 50g/bird = 50g higher BW at 7 days and 1.6% more breast muscle at processing.
Why do we care about 7 d BW?

For every 10 g of extra BW at 7 d, there is an additional 50 to 70 g of BW on the 42 d broiler.
Dietary Particle Size

Breeding Company Manuals:
- 0-10 d = sieved crumb
- 11-28 d = 2–3 mm diameter pellet
- 29 d to processing = 3 mm diameter pellet

No optimum particle size for the raw materials of a pellet
- Mill:mill effects
- Final pellet size and quality more important
Measuring Feed Separation

Table 7: Recommended particle size distribution for crumble or pelleted feeds.

<table>
<thead>
<tr>
<th>Form</th>
<th>Starter</th>
<th>Grower</th>
<th>Finisher</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Crumb</td>
<td>Pellet (3.5 mm)</td>
<td>Pellet (3.5 mm)</td>
</tr>
<tr>
<td>&gt; 3 mm</td>
<td>15%</td>
<td>&gt;70%</td>
<td>&gt;70%</td>
</tr>
<tr>
<td>&gt; 2 mm</td>
<td>40%</td>
<td></td>
<td>20%</td>
</tr>
<tr>
<td>&gt; 1 mm</td>
<td>35%</td>
<td>20%</td>
<td>20%</td>
</tr>
<tr>
<td>&lt; 1 mm</td>
<td>&lt; 10%</td>
<td>&lt; 10%</td>
<td>&lt; 10%</td>
</tr>
</tbody>
</table>
Pre-brooding & Brooding

Receiving and starting chicks
- one of the most difficult yet important stage in growing broilers

Take special care to ensure chicks are started properly
- houses must be ready BEFORE chicks arrive
- exploit genetic potential of chicks

Not properly pre-conditioning barn one of the biggest mistakes we see – especially in cool weather
Pre-brooding & Brooding

Why does this matter?

- The chicken is most efficient at 1 day of age
- Performance in terms of growth and FCR seems small in absolute terms, but FCR is most efficient and economical during this period
- Proper temperature control not fully effective until 3 wk of age (but especially problematic in first few days post-hatch)
Blue: Chicks are cold-blooded, environment crucial
Orange: Transition period around 5 days old
Red: Warm-blooded, chicks produce their own heat and can regulate their temperature themselves
Use Humidity Value to Help Decide Ideal Barn Temperature
Effective Temperature

Table 3: Dry bulb temperatures required to achieve equivalent temperatures at varying RH. Dry bulb temperatures, at the ideal RH at an age, are colored red.

<table>
<thead>
<tr>
<th>Age (Days)</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day-old</td>
<td>36.0 (96.8)</td>
<td>33.2 (91.8)</td>
<td>30.8 (84.4)</td>
<td>29.2 (84.6)</td>
<td>27.0 (80.6)</td>
</tr>
<tr>
<td>3</td>
<td>33.7 (92.7)</td>
<td>31.2 (88.2)</td>
<td>28.9 (84.0)</td>
<td>27.3 (81.1)</td>
<td>26.0 (78.8)</td>
</tr>
<tr>
<td>6</td>
<td>32.5 (90.5)</td>
<td>29.9 (85.8)</td>
<td>27.7 (81.9)</td>
<td>26.0 (78.8)</td>
<td>24.0 (75.2)</td>
</tr>
<tr>
<td>9</td>
<td>31.3 (88.3)</td>
<td>28.6 (83.5)</td>
<td>26.7 (80.1)</td>
<td>25.0 (77.0)</td>
<td>23.0 (73.4)</td>
</tr>
<tr>
<td>12</td>
<td>30.2 (86.4)</td>
<td>27.8 (82.0)</td>
<td>25.7 (78.3)</td>
<td>24.0 (75.2)</td>
<td>23.0 (73.4)</td>
</tr>
<tr>
<td>15</td>
<td>29.0 (84.2)</td>
<td>26.8 (80.2)</td>
<td>24.8 (76.6)</td>
<td>23.0 (73.4)</td>
<td>22.0 (71.6)</td>
</tr>
<tr>
<td>18</td>
<td>27.7 (81.9)</td>
<td>25.5 (77.9)</td>
<td>23.6 (74.5)</td>
<td>21.9 (71.4)</td>
<td>21.0 (69.8)</td>
</tr>
<tr>
<td>21</td>
<td>26.9 (80.4)</td>
<td>24.7 (76.5)</td>
<td>22.7 (72.9)</td>
<td>21.3 (70.3)</td>
<td>20.0 (68.0)</td>
</tr>
<tr>
<td>24</td>
<td>25.7 (78.3)</td>
<td>23.5 (74.3)</td>
<td>21.7 (71.1)</td>
<td>20.2 (68.4)</td>
<td>19.0 (66.2)</td>
</tr>
<tr>
<td>27</td>
<td>24.8 (76.6)</td>
<td>22.7 (72.9)</td>
<td>20.7 (69.3)</td>
<td>19.3 (66.7)</td>
<td>18.0 (64.4)</td>
</tr>
</tbody>
</table>

*Temperature calculations based on a formula from Dr. Malcolm Mitchelli (Scottish Agricultural College).*
Effective Temperature

*The perceived temperature reduction with increased air movement*
Effective Temperature

\[ \sim 150 - 200 \text{ Ft/Min} \quad \sim 250 - 300 \text{ Ft/Min} \]
Chilled chicks due to over ventilation
Supporting Early Growth by Monitoring Crop Fill

Monitor in first 48 hours
- Confirms birds ability to eat and drink.
- 80% - 8 hours after delivery
- 95% - 24 hours after delivery

Consider scoring amount of crop fill
- 0 = nothing
- 1 = size of chick pea
- 2 = size of grape

Crop fill can be used at any age as measure of bird comfort
Brooding: Practical Steps

• Feed birds as soon as they arrive on farm
• Target coverage of 50% of floor area with paper
• Put at least 65 gm feed per chick on paper
• Tip the chicks onto feed area, not on litter
• Check crop fill 12 and 24 hrs after placement
• 12 hrs 80% with feed and water in the crop
• 24 hrs, >97% with feed and water in the crop
Origins of centralized hatching: Egyptian egg ovens
Technology and Incubation
Broiler Breeder Farm and Hatchery Effects

Broiler breeder flock fertility and hatch rate
- Male management or male line choice

Incubation / hatch effects
- Incubation temperature (especially in last week)

Clean egg from hatching egg farm?
- Reduced hatchability of floor eggs (82% vs 62.1%) and washing does not help (63.1%) \(\text{Van den Brand et al., 2016}\)

Egg Handling (bumps, storage temperature etc.)

Traditional vs. In-barn hatching?
- Examples = HatchCare and X-Treck
- In-barn hatching = higher hatch size and early gut growth
- May see better final uniformity due to better growth in early-hatched birds
Role of Egg Handling and Transport

Success or failure of egg transport and storage has strong links back to the hen diet and breeder farm management

- Egg size
- Shell quality
- Lipid stability (antioxidants)
- Barn environment (especially temperature)
- Barn biosecurity (rodents, insects)
Role of Egg Handling and Transport

Diagnositics of issues:

- Egg collection
  - Frequency, temperature, equipment issues

- Egg storage at farm
  - Temperature / humidity

- Egg transport to hatchery
  - Equipment, procedure, difference in environment

- Egg transfer to hatchery storage
Vitamin D Source Affects Hatchability

Early Mortality

P = 0.02

Late Mortality

P = 0.84

- 3,000 IU D3
- 3,000 IU D3 + 34.5 µg 25-OH D3
White Blood Cell *E. coli* Killing Late Production (61 wk)

P <0.0001

% E. coli Killed

1 d 4 d

Control 25-OH D3

P <0.0001

% E. coli Killed

1 d 4 d

Control 25-OH D3

P <0.0001

% E. coli Killed

1 d 4 d

Control 25-OH D3
Shell Quality: Need **Large Particle Size Calcium Source**

![Bar chart showing P Retention affected by CaCO$_3$ Particle Size](image)

- **P Retention**
  - Large: 28.4%
  - Small: 22.8%

- **p-value**: 0.13

**Note:** The image contains a bar chart illustrating the difference in P retention between large and small CaCO$_3$ particle sizes, with a p-value of 0.13 indicating a statistically significant difference.
Yolk Deposition

- Each day there is deposition of denser yolk (slower deposition) and less dense yolk (rapid deposition with blood filled with yolk materials in response to feeding)
Egg Transport Issues

Diagnose issues with examination of steps
- Use commercial ‘test-egg’ to record temperature, humidity, and bumps

Upgrade equipment or change procedures as is feasible
- Egg carts with shock-absorbing wheels
- Air-ride suspension trucks (temperature-controlled)
Egg Transport Issues

Alternatives if infrastructure issues:
- Ship eggs at night for cooler temperature
- Avoid rough roads (even if longer drive)
- Fix bad farm accesses
- If applicable: Paper-fiber trays rather than hatchery incubator trays to provide extra protection

Often see a 1-3% increase in hatchability with each of the more serious issues.
Chick Quality Essential: Keeping your broiler production value chain clean

<table>
<thead>
<tr>
<th>Egg condition</th>
<th>Total bacteria</th>
<th>Coliforms</th>
<th>14 day mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean</td>
<td>600</td>
<td>123</td>
<td>0.9</td>
</tr>
<tr>
<td>Soiled</td>
<td>20,000</td>
<td>904</td>
<td>2.3</td>
</tr>
<tr>
<td>Dirty</td>
<td>80,000</td>
<td>1,307</td>
<td>4.1</td>
</tr>
</tbody>
</table>

Contaminated eggs increase broiler disease and mortality
Floor Eggs and Egg Sanitation

Floor eggs: As eggs cool in dirty environment, pull bacteria into pores.

Dirty Eggs: Surface biological contamination
  ◦ Breeder guidelines: Size of a dime maximum before discard

Some farms try to ship every egg because it is a potential chick.
  ◦ When segregate floor and washed eggs in hatchery, can see 10-20% hatchability
## Comparison of Egg Washing Methods

<table>
<thead>
<tr>
<th>Rank</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>EGG WASHING MACHINE</td>
</tr>
<tr>
<td>2</td>
<td>AERATED AGITATION IN EGG WASH</td>
</tr>
<tr>
<td>3</td>
<td>CLOROX WIPES</td>
</tr>
<tr>
<td>4</td>
<td>RUNNING WATER</td>
</tr>
<tr>
<td>5</td>
<td>ADDING EGGS TO A TUB OF WATER + EGG WASH, AND SOAKING</td>
</tr>
<tr>
<td>6</td>
<td>AERATED AGITATION IN WATER</td>
</tr>
<tr>
<td>7</td>
<td>ADDING WATER TO A TUB OF EGGS AND SOAKING</td>
</tr>
<tr>
<td>8</td>
<td>ADDING WATER + EGG WASH TO A TUB OF EGGS, AND SOAKING</td>
</tr>
<tr>
<td>9</td>
<td>ADDING EGGS TO A TUB OF WATER AND SOAKING</td>
</tr>
<tr>
<td>10</td>
<td>ROUGH SPONGE</td>
</tr>
<tr>
<td>11</td>
<td>SANDPAPER</td>
</tr>
</tbody>
</table>

The chart indicates the best and worst methods for egg washing. The best method is EGG WASHING MACHINE, while SANDPAPER is the worst method.
Comparison of Egg Washing Methods

Follow-up hatch project showed bacteria still in pores after any wash method.

Even UV treatment could not resolve high bacterial numbers

You cannot ‘fix’ an un-settable egg

Un-settable eggs contain 44x the amount of bacteria in the pores when compared to a dirty egg that has been washed and a clean egg.
Embryo Heat Production

Old genetic lines 0.1 Watt/egg

Hulet and Meijerhof:
○ .14 to .16 Watt/egg
○ Later trials: 0.2 to 0.3 Watt/egg
○ Based on carbon dioxide production

Lourens: 0.16 Watt/egg at 16 days

27 to 173% Increase in heat production
○ More heat to remove with modern genetics
Incubation temperature and embryonic heat production during d 15 to 21 in Ross 708

37.5 C birds “stall” at 17 d. Because it is too hot, growth is stunted.
Late incubation overheating also negatively affects broiler breast muscle yield.
1. Hatchery

1.24. How to establish good chick quality? - Colibacillosis control

Consequences of overheating embryos
E. Coli susceptibility *(Trial Cobb Spain, 2011)*

It is not clear if overheated embryos are more sensitive because they spend longer in the hatchers (hatch early), but the % of E.Coli isolations seem to increase with:

- Hours of incubation
- Bigger yolk sacs

![Graphs showing % Chicks with E.Coli vs. hours of incubation and % Chicks with E.Coli vs. residual yolk sac size.](image)
How do we navigate these changes?

“How technology and data management, regulatory challenges and implementation, and the need to tell our story, justify our decisions and connect meaningfully with consumers alongside making daily decisions regarding the business which I run... It is becoming overwhelming. But as a farmer I feel a lot of pressure to do it all to protect my industry.”

Quote from an Alberta farmer, 2021
Thank you

Robert Renema
rrenema@chicken.ab.ca
robert.renema@gmail.com
780-918-1015