Gut health in poultry

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Gut anatomy, development and function
Gut overview

- Gut health is essential for good growth and FCR
- Gut health relies on acquisition and maintenance of a balanced gut flora
- Gut health relies on the proper development of the gut tissues
- Intestinal tract is the largest organ in the body
- Contains ~70% of a bird’s immune cells
- Intestinal tract is larger in terms of % of overall body weight early in life
Gut overview

- A specialised tube running from beak to the cloaca where feed is digested and absorbed
- Divided into distinct regions
- Each region has a specific role
- Each region has a specific structure
Gut anatomy and appearance:

**Small intestine:**

Feed is mixed with bile, bicarbonate and enzymes to start digesting the lipids, proteins, sugars in the diet.

The resultant molecules are then absorbed through the gut wall for transport around the body.

The villi and microvilli in the small intestine provide a large surface area for this to occur.

**Large intestine**

The caeca is the site of major bacterial fermentation.

Caecal contents consist of the material the bird is unable to digest or which has not been absorbed.

From this the bacteria produce shortchain fatty acids, organic acids, vitamins and other nutrients that can be absorbed by the host.

The colon is a short region where some water absorption occurs.

**Proventriculus:**

- Proventriculus secretes acid and pepsin
- Feed stays in this region for short time
- pH 2.5-3.5

**Gizzard:**

- Mechanically grinds the feed
- Tough inner koilin layer
- Thick outer muscular layer
- Sets the rate of feed passage
The result of good digestion!

Very important to recognise the difference in these types of droppings
• Consequence of impaired digestion
  – Feed passage
  – Fatty and wet faeces
  – Poor FCR
Gut development

• Day 17 of incubation till hatch – key period
  – An indicator of poor in-egg development is poor gut tone

• After hatch the gut starts to mature
  – Switch from yolk nutrition to external feed
  – Enzyme production increases
  – Immune system starts to mature
  – Gut flora starts to colonise

• First 10 days when villi undergoing rapid development
  – Maximum development at 4 days in duodenum and 10 days in jejunum and ileum

• If the birds are stressed likely to impair gut maturation
• Villi development

Factors such as cold stress and poor feed/water access can impair this development.

A key aspect of villi development is stimulation from the gut microbiota.
• Impact of poor development

- poorly developed
  - Cocci infection
  - Villi become fatter and shorter
  - Ability to absorb nutrients is reduced

- well developed
  - Less impact on ability to absorb nutrients
Scanning electron micrographs

- They are long and free with intact villi tips
- Microvilli are even and regular
Poor villi. There is severe erosion of the villi tips

layers of enterocytes appear to be peeling away from the villi core

The microvilli appear stunted and irregular
Monitoring gut health
Indicators of poor gut health

- A gut health problem usually manifests itself with
  - Poor growth rates
  - Flock uniformity
  - Wet litter
  - Wet faeces
  - Feed passage
  - Frothy caecal droppings
Gut Scoring

• Giving a gross overview of gut function
  – Ongoing infections or disruptions of gut function
  – Efficiency of absorption of nutrients

• In younger birds (e.g. 7 days)
  – Can indicate quality of brooding

• Can give an indication of underlying gut issues
  – Malabsorption
  – Poor uniformity
  – Feed quality

• Also allows a flock to flock measure of gut health
Gut Scoring

- Birds scored:
  - Redness of the mucosa
  - Wetness of the gut contents
  - Tone of the gut wall

<table>
<thead>
<tr>
<th>Bird ID: Bird Breed:</th>
<th>Gizzard Erosion</th>
<th>Coccidiosis</th>
<th>Feed passage</th>
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<tbody>
<tr>
<td></td>
<td>0 1 2</td>
<td>0 1 2</td>
<td>Yes No</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Redness</th>
<th>Gut tone</th>
<th>Consistency of contents</th>
<th>Mucus</th>
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<tbody>
<tr>
<td>Duodenum</td>
<td>0 1 2</td>
<td>0 1 2</td>
<td>0 1 2</td>
<td>Yes No</td>
</tr>
<tr>
<td>Jejunum</td>
<td>0 1 2</td>
<td>0 1 2</td>
<td>0 1 2</td>
<td>Yes No</td>
</tr>
<tr>
<td>Ileum</td>
<td>0 1 2</td>
<td>0 1 2</td>
<td>0 1 2</td>
<td>Yes No</td>
</tr>
<tr>
<td>Caeca</td>
<td>Colour: Dark Light Consistency: Watery Pasty</td>
<td>Foamy Gassy</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Other notes:
Gut scoring

• Is there mucus present?
  – In the duodenum mucus is common
  – In jejunum and ileum you shouldn’t see mucus

• Is there feed passage?

• What do the caeca look like?
  – Presence of gas
  – Consistency
  – Colour
Caecal characterisation

- Normal
- Mild imbalance
- Severe imbalance
Gut histology

• Histology can help us explain changes we see in gut morphology

• Highlight sub-clinical disease
  – Coccidiosis
  – Viruses

• Show appropriate development
  – Highlighting previous challenges (management and disease)
Cocci in the gut

- It is sometimes possible to see the effects of subclinical coccidiosis at the gut surface.

Normal even layer of villi

During cocci infection the villi become shorter and fatter resulting in a distinctive pattern.
Cocci in the gut

- Electronmicroscopy can show this nicely

Normal villi

Cocci infected villi. This is the pattern you can see
Gut Microbiota
• Gut Microbiota
  – Community of bacteria, viruses, fungi and protozoa living in the gut
  – Approximately 700-800 species of bacteria in the chicken gut
  – Bacterial cells outnumber host cells 10:1
  – Consumes ~20% of dietary energy
  – Highly metabolic organ
Importance of the microbiota

• Helps to direct the development of gut structure and gut immunity
  – Different bacteria influence the gut in different ways

• Modulates the immune response

• Aids digestion

• Produces nutrients from non-digestible dietary components

• Offers protection from gut pathogens
Development of the microbiota

• The microbiota of a chicken takes a few weeks to fully mature
  – Crop colonised within 24 hours
  – One day post-hatch the ileum and caeca are both dominated by bacteria
  – After three days these levels increased 10-fold
  – Within two weeks the adult small intestinal microbiota will be established
  – After 30 days the caecal flora will have stabilised

• During this time the microbiota can be disturbed leading to dysbacteriosis and/or wet litter.

• Essential to ensure the gut gets a good start to ensure quicker maturation of microbiota
Which bacteria are present?

• Small intestine
  – Dominated by lactic acid producing bacteria (Lactobacillus and enterococcus)
  – These dominate the gut throughout the life of the bird but the species differ as the birds age

• Large intestine
  – Early in life lactic acid producers and bacteroides
  – Later in life fermentative clostridia and bacteroides

Under normal circumstances the flora contains favourable and less favourable bacterial species
Development of the microbiota

• Where do the pioneering bacterial species come from?
  – Hatchery environment
  – Hatchery staff
  – Farm environment
  – Feed

• On the farm chicks will be exposed to the remaining flora from the previous flock
  – Impact on chicks
  – Wet vs dry cleaning
Intestinal microbiota fluctuations

Bacterial populations in different gut regions

- Good ileum
- Poor ileum
- Good caeca
- Poor caeca

Percentage of population:

- Subdoligranulum
- Parasutterella
- Parabacteroides
- Oxobacter
- Holdemania
- Dorea
- Corynebacterium
- Coprobacillus
- Bacteroides
- Anaerotrunccus
- Anaeroplasma
- Acetitomaculum
- Acetanaerobacterium
- Blautia
- Coprococcus
- Sporobacter
- Papillibacter
- Ruminococcus
- Odoribacter
- Faecalibacterium
- Butyrificoccus
- Acetivibrio
- Barnesiella
- Alistipes
- Other
- Staphylococcus
- Lactobacillus
Microflora during upset

• Shifts in microbiota are indicative of malabsorption
  – Poor fat absorption
  – Sugar, fat and protein available in the caeca

• More nutrients for bacteria

• Bacterial overgrowth
  – $\text{CO}_2$, $\text{CH}_4$, $\text{H}_2\text{S}$ produced
  – Toxic amines (irritates gut and causes growth depression)
  – Bile acid inactivation (impairs fat absorption)

• Leads to further digestive upset
Factors affecting gut environment

- Gut health and microbial community affected by
  - Feed substrate – Cereal, protein and fat type
  - Feed form – mash/crumb/pellet
  - pH
  - Viscosity and water content
  - Nutrient density
  - Overall bird health – stress, immuno-suppression etc.
  - Early gut development
Gut microbiota and gut health

- It is easy to simply focus on which bacteria are in the guts
  - Gut health is based on the dynamic between many factors
  - Gut microbiota will fluctuate naturally
  - Often the microbiota seen in a gut upset is a secondary affect
  - In the absence of a properly developed gut the bacterial population will never be stable
Influencing gut health
Influencing gut health

• On the farm gut health can be influenced from day 1
  – Key aspect is to get feed into the chick to feed the gut
  – Correct brooding temperatures
    • Too hot the chicks don’t want to eat
    • Too cold and the chicks huddle and don’t eat
  – Good access to feed and water
• By doing this the gut development is optimal
• Ensure the birds are equipped to cope with gut challenge
Products to improve gut health

- **Direct fed microbials**
  - **Probiotics**
    - Defined bacterial products (<10 strains)
    - Lactic acid producers
      - Lactobacillus, enterococcus, pediococcus etc.
    - Bacillus products
      - Microbiota modulators
      - Fed in feed or added direct to litter
  - **Competitive exclusion agents**
    - Undefined bacterial products
      - Aviguard
      - Broilact
Organic acids
- Often only active in the foregut (Crop, gizzard, duodenum)
- Lower pH
- Provide nutrients for other bacteria (Lactic acid)
- Antibacterial (Acetic, formic, benzoic)
- Stimulate gut tissues (Butyric, propionic)

Phytobiotics
- Essential oils (Oregano, thyme, clove, cinnamon)
- Antibacterial
- Gut stimulatory

Interestingly organic acids and essential oils seem to work better together
Products to improve gut health

- **Oligosaccharides**
  - **Fructo-oligosaccharides (FOS) – Prebiotics**
    - Provide a dedicated nutrient source for fermentative bacteria
    - Chicory root, fruit pectin
    - Often included in probiotic mixes
  - **Mannan-oligosaccharides (MOS)**
    - Yeast cell wall
    - Block attachment of *E. coli, Salmonella spp.* to the gut wall
  - **Lactulose**
    - Sugar substitute
    - Fermented by bacteria
    - Often in probiotic mixes
Reason for using these products

- Improve gut integrity
- Stimulate or provide a beneficial flora
- Improve gut function
- Inhibit pathogens
- Reduce antibiotic usage
- **Alternative to Antibiotics?**
  - Preventative rather than therapeutic
  - One product to fit all situations?
• **Do they work?**
  - They work with the right product given at the right time in a bird’s life in the right manner.
    - Early in life
    - 3-5 days over a stressful event
    - Feed vs water
  - All experimental data will show they work
  - Have to remember there is no one product that will help in all situations
  - Choose a product that is suited to your management strategy and the problem you see
Examples of improper use

Giving a probiotic if:

- You regularly use antibiotic growth promoters
- If your water supply is heavily chlorinated (>5ppm)

Why? These are likely to kill off any probiotic
Solution: Use a product to stimulate the gut such as a prebiotic or organic acid.

Giving a probiotic at the hatchery with antibiotics

Why? Probiotic bacteria will be killed by the antibiotic
Solution: Use a probiotic after any antibiotic use to repopulate the gut.
Use a prebiotic such as MOS to prevent attachment of less favourable bacteria
If the development of the gut and the establishment of a healthy gut flora is disrupted the gut will **not** function correctly as the birds age.

If the gut flora is compromised it is essential to support its re-establishment.

Any antimicrobial therapy will impact upon the gut flora and thus gut development.

Subclinical and background challenges can cause a gut imbalance.

These must be understood.

Summary

Exposure to the correct gut flora early in life will assist gut development.

Water treatments will impact upon the gut flora by either killing the gut flora or altering the pH.

Feed quality and composition plays a major role in gut health.

Gut development starts in the egg.

Optimal incubation conditions are critical.

Any antimicrobial therapy will impact upon the gut flora and thus gut development.

If the gut flora is compromised it is essential to support its re-establishment.
Thank you!

Questions?

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