POLLTRY MICROBIOTA

The poultry gut harbours a complex and dynamic microbiota whose role is essential in digestion and health. Find out more in this series of short articles.

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Meet the Microbes

The gut microbiota includes a majority of commensal species as well as potential pathogenic ones. It is composed of thousands of different strains and species of bacteria, yeasts, viruses, and archaea.

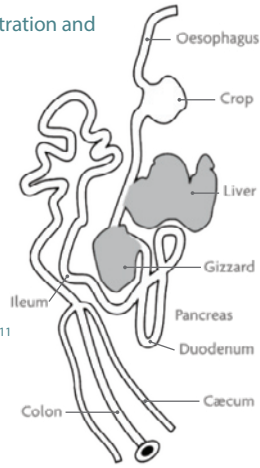
Each part of the poultry digestive tract offers a different habitat in terms of nutrients, pH conditions, but also feed retention time. From the crop to the caecum, the composition, concentration, and diversity of the microbiota is highly variable (Fig. 1). However, in birds, microbiota diversity is fairly low when compared to bigger animals, probably due to the short transit time: typical retention time for a 29-day-old broiler is between 4-5 hours compared to humans where the average is 20 hours.

Fig. 1. Repartition of the microbiota populations along the poultry digestive tract.

Crop – Gizzard: Low bacteria concentration and diversity (10^3–10^5 CFU/g)
1. *Lactobacillaceae*
2. *Enterococcaceae*
3. *Enterobacteriaceae* i.e *E. coli*

Small intestine: High bacteria concentration (10^8–10^9 CFU/g)
1. *Lactobacillaceae*
2. *Clostrodiaceae*
3. *Enterococcaceae*

Caecum: Very high bacteria concentration and diversity (10^{10}–10^{11} CFU/g)
1. *Clostrodiaceae* i.e *Clostridium Perf.*
2. *Fusobacteriaceae*
3. *Bacillaceae*



The chick's microbiota establishment takes several days after hatching, a time when the birds are particularly sensitive to enteropathogen contaminations. The primary roles of this microbiota are 1) to aid in digestion 2) to safeguard the organism against pathogens and reinforce immunity.

The poultry gut microbiota is a fragile ecosystem that can be disturbed by many factors, such as vaccination, pathologies, drugs, antimicrobial treatments, heat stress, sexing, feed transition, building changes etc.

A method to assess the equilibrium of the gut microbiota at farm level is to analyse the faecal microflora and look at the ratio between two bacterial populations, one beneficial, such as Lactobacilli and the other potentially at risk, such as coliform. It can be a good indicator of a flock status. It has been shown in various conditions that feeding selected probiotic bacteria to poultry helps improve the ratio between lactic acid bacteria and enterobacteria populations.

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POULTRY MICROBIOTA

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A key role in digestion

Providing 5-30% of energy

About 55-70% of a poultry feed formula is made up of cereals, the major source of carbohydrates, hence energy, for the birds. However, only simple carbohydrates such as starch are digested through an enzymatic process in the small intestine. The major part of complex carbohydrates and fibres present in the diet cannot be digested by the bird's enzymes. Only certain microorganisms from the gut are able to digest these.

In the caecum, commensal microorganisms are able to hydrolyse the poly-, oligo- and di-saccharides into primary sugars. These are then further fermented into short chain fatty acids (SCFA) and volatile fatty acids (VFA), which are mainly absorbed at the level of the caeca, providing additional energy to the bird.

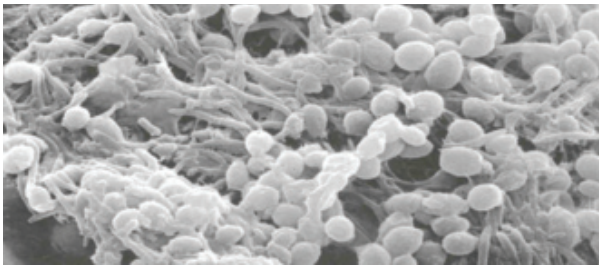
It is estimated that the part of total energy requirement for poultry coming from fermentation ranges between 5 and 30%, depending on the diet.

Supporting the digestive function

The gut microbiota not only takes part in energy metabolism, but also influences the whole digestion process. Microbiota presence in the poultry gut also plays a role in intestinal absorption. The microbiota can be associated with:

- Increased villi height.
- Improved micronutrients absorption.
- Higher enzymatic activity.

The microbiota plays a role in protein and lipid metabolism, vitamins and mineral absorption, also providing some of the essential nutrients that the host's own enzymatic system is unable to produce (for example, vitamin K).



Caecal mucosa in the presence of *Saccharomyces cerevisiae boulardii* (Corthier,

Many stress factors such as heat stress, sexing, feed transition, vaccination, pathologies, drugs, building transfer etc can affect the gut microbiota balance. As a consequence, growth and performance are affected.

Recent research has shown that feeding hens with a lactic acid bacteria known to balance the gut microbiota is able to improve feed efficiency and energy metabolism.

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The guardian of poultry immunity

The digestive tract represents one of the major sites of exchange between the animal and its environment and enteric pathogens are an important threat to modern poultry operations. The gut is also a major site of defence for these organisms, first through its gut wall barrier and also through the presence of many primary and secondary immune organs.

Triple protection

The gut microbiota plays a protective role at three main levels:

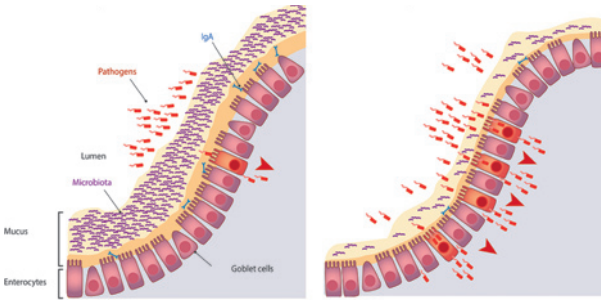
1. **A barrier effect:** by adhering to the gut wall lining the commensal bacteria prevent the colonisation by potential pathogens, this is the competitive exclusion effect.

2. **In the gut lumen**, various anti-pathogens strategies are linked to the metabolism of the microbiota, such as the production of lactic acid, which acidifies the gut environment. Such conditions prevent the development of most pathogens which thrive under high pH (coliforms, *salmonella*). Other commensal bacteria also produce antimicrobial metabolites.

3. **Through modulation of the immune system:** modulation of the inflammation and stimulation of the immune response.

An inflammatory state, linked to stressful situations, pathogen pressure etc, has been linked to a drop in performance in poultry which can be explained by two factors:

- Energy diversion towards the immune response and not growth or egg production. Up to 30% of the energy can be lost for the activation of the immune system and management of inflammation.
- Drop in feed intake.



Left, a healthy microbiota and, right, a depleted microbiota.

A well balanced, healthy microbiota is key to preserving gut health in poultry production. Supplementation of the poultry diet with selected probiotic microorganisms, such as *Saccharomyces cerevisiae boulardii*, has proven benefits on the three levels of the gut barrier and has been shown to reduce faecal contamination with *Salmonella spp.* in broilers for example.

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POLYTRICHOTA

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The competitive exclusion concept

Competitive exclusion is defined as the phenomenon whereby normal healthy intestinal bacteria colonise the intestine and prevent colonisation by transient pathogenic bacteria. This concept has been developed and applied to help improve the chick's microbiota establishment and protect them from pathogens.

The birth of a concept

In the 1950s and 60s, with the intensification of chicken rearing, the issue of salmonella contamination in meat emerged. Researchers started to look at preventative approaches. It was clear that as chickens grow older they become more resistant to salmonella gut colonisation. This led to the thought that maturation of the gut could prevent salmonella from colonising the guts of older birds, and the microbiota was quickly suspected to be involved in this resistance. In nature, the bird microbiota comes from the environment and mother hens. In intensive rearing conditions, as the eggs are hatched in near sterile conditions in incubators, the development of a normal gut microbiota could be impaired or at least delayed. A partially developed microflora could leave more room for potential pathogens, such as salmonella, to colonise the gut. This led to the competitive exclusion (CE) concept. Initially, researchers fed diluted gut contents of mature, free-range hens to intensively reared chicks, which showed an increased resistance to salmonella contamination. The Finnish microbiologist Professor Nurmi defined this concept in Nature in 1973. Competitive exclusion was born.

A great tool against enteropathogens

The science behind the concept and its applications have evolved. Today, we no longer use minced gut from adult chickens. Commercial products have been developed based on the industrial propagation of healthy adult chicken gut microbiota under controlled conditions. If the concept was originally designed for salmonella reduction in chicken, it has also expanded to other enteropathogens such as E. coli, Clostridium perfringens, listeria or campylobacter, and to other avian species (turkeys, pheasants and quails). The main mechanisms involved in competitive exclusion have been described as:

- Direct attack: production of bacteriocins and organic acids that can damage pathogenic bacteria.
- Nutrient competition: competition for the nutrients available in the gut.
- Receptor competition: competition for attachment sites on the gut enterocytes.
- Immune stimulation: of the non-specific immune system of the gut by the normal microflora.
- Physical barrier: a bacterial mat blocking access to the mucosa.

Even though competitive exclusion is nearly 50 years old, it remains a promising concept for modern poultry production.

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