

Gut Health in Turkeys - The World Within

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Summary

A healthy gut is essential for the efficient conversion of feed into its basic components for optimal nutrient absorption. If gut health is compromised, digestion and nutrient absorption will be affected, and bird health, performance and welfare will be compromised.

Gut Inhabitants

The gastrointestinal tract (GIT) consists of a diverse community of mainly bacteria, fungi, protozoa, and viruses (gut microbiota). The major development of this community begins on hatching; bacteria are picked up from the environment, the feed, and the people handling the poulters post-hatch. Each of these three areas can therefore affect gut microbiota development.

Maintaining the Balance of Gut Health

Maintaining good gut health is critical for maintaining the growth, health, and welfare of the bird. If digestion and nutrient absorption is compromised an imbalance or overgrowth of the gut microbiota can occur which in turn will affect bird health and performance. The balance of the microbiota in the gut can be significantly affected by bird management and environment.

- **Diet** – feed changes, raw materials, and physical quality all influence the balance of the gut microbiota.
- **Brooding conditions** – the provision of optimal brooding conditions is essential for ensuring optimal gut microbiota development. Birds receiving appropriate brooding develop a gut that performs well and has a greater capacity to cope with the challenges of the turkey shed. Early access to feed and water is essential.
- **Biosecurity** – if clean-out and disinfection procedures are inappropriate, pathogens will be introduced into the poultry shed, exposure to these pathogens will influence gut health and development.
- **Risk periods** - there are times during poultry production when the bird will be challenged, for example during feed change-overs or vaccination. During these periods, the gut microbiota can fluctuate and in some cases, if management is sub-optimal, dysbacteriosis can occur.
- **Environmental conditions** - temperature and ventilation. Achieving optimal environmental conditions will promote good gut health.
- **Mycotoxins** and infections will also impact gut health.

Conclusion

Maintaining the balance of good gut health is a key aspect of ensuring the best bird performance and health. Management styles, climate, disease, and feed raw materials all affect gut health. Good bird management practices (brooding, feed, water, biosecurity, and environment) are necessary to maintain gut health and therefore bird health, welfare, and performance.

Introduction

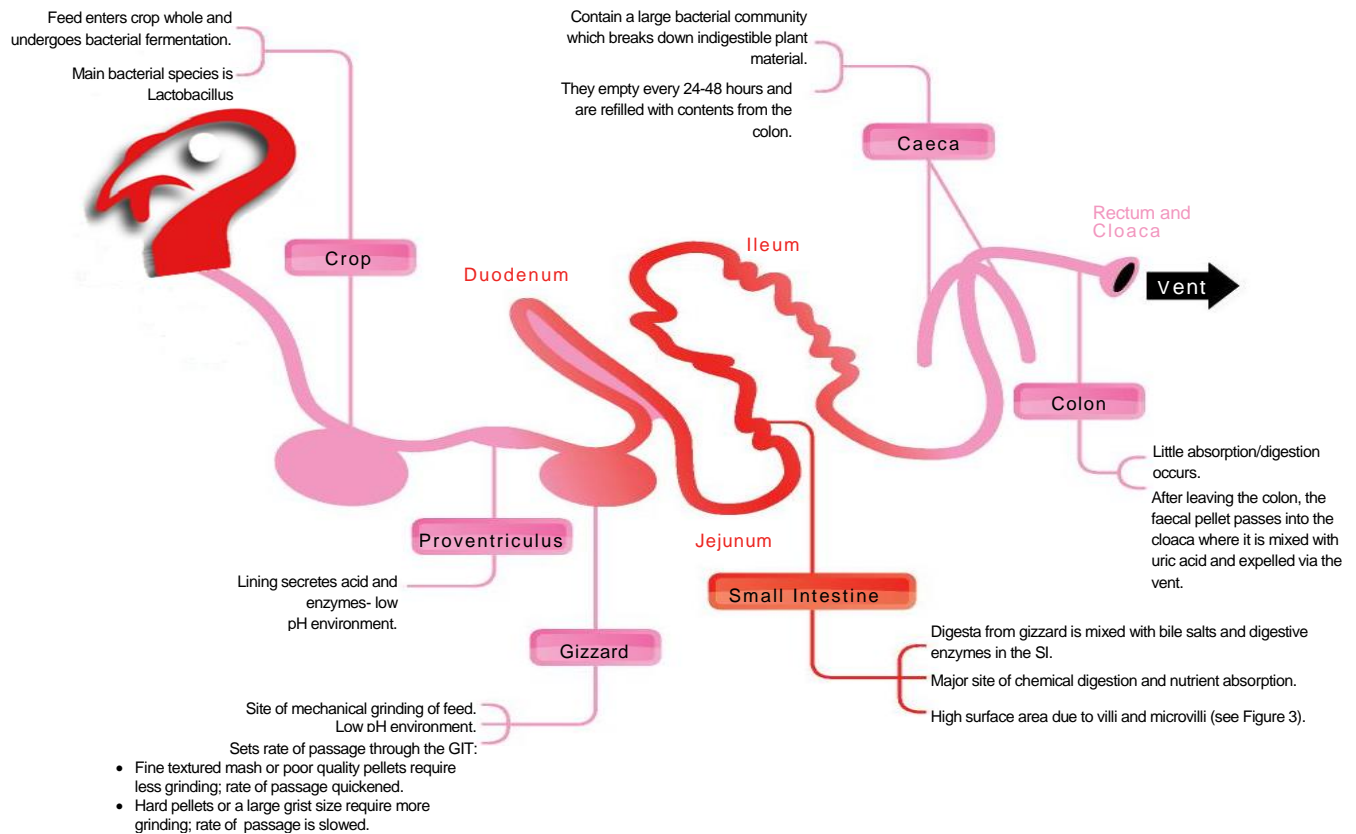
The efficient conversion of feed into its basic components for optimal nutrient absorption is vital for both commercial and turkey breeder production and welfare. Gut health, an intricate and complex area combining nutrition, microbiology, immunology and physiology, has a key role to play. When gut health is compromised, digestion and nutrient absorption are affected which, in turn, can have a detrimental effect on feed conversion leading to economic loss and a greater susceptibility to disease. In addition, recent changes in legislation on the use of antimicrobials, differing feed requirements and more efficient birds highlight the need for a better understanding of gut function and gut health. This article aims to

explore the area of gut health and outline key factors that are important in the development and maintenance of optimal gut function

An Overview of the Gut and How it Works

The intestinal tract of a bird is a specialised tube that starts at the beak and ends in the cloaca. The primary function of the gut is the conversion and digestion of food into its basic components for absorption and utilization by the bird.

The gut is separated into 5 distinct regions (Figure 1): the crop, proventriculus, gizzard, small intestine (duodenum, jejunum, and ileum), and large intestine (caeca, colon and rectum).



Each of these regions has a specific role in the digestion process and absorption of nutrients. The feed enters the crop where it is stored for a short period of time and partially fermented by the resident bacteria. The feed then enters the proventriculus where it is mixed with acid and pepsin (an enzyme which breaks down protein) and then on to the gizzard. The gizzard acts like a grinding mill to break the feed into smaller particles, it will then release the feed into the small intestine once the feed particles are small enough. Whilst the gizzard grinds the feed it is mixed with the acid and enzymes secreted by the proventriculus. This process allows for the break down whole proteins into smaller peptides which can then be digested in the small intestine into amino acids for absorption. Within the small intestine the carbohydrates and fats are also broken down so that they can be absorbed and used by the birds. During the normal digestion process, by the time the digesta reaches the last part of the ileum all the proteins, fats and carbohydrates should have been absorbed leaving behind the non-digestible components of the feed (e.g. cellulose, non-starch polysaccharides etc.). This material has two fates; it is either passed out in faeces or taken up by the caeca where bacteria ferment these materials to form organic acids, short chain fatty acids and vitamins which the bird can absorb for extra nutrients. At the end of digestion turkeys will produce two types of dropping a caecal and a faecal which look very different (Figure 2).

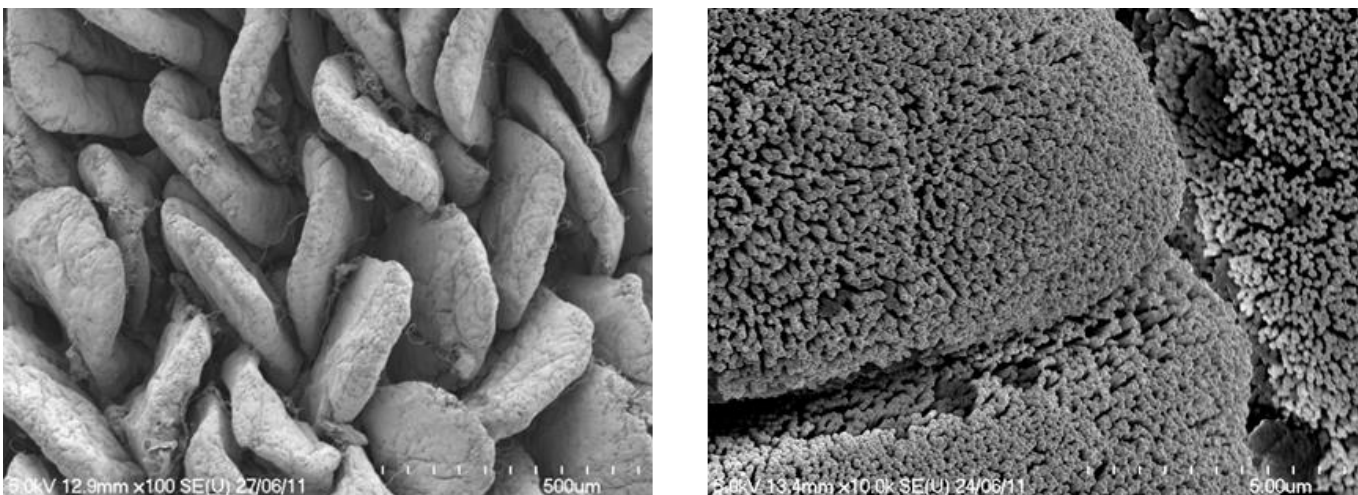
Key Management points

- The gut is responsible for the digestion and absorption of nutrients.
- If gut function is impaired, digestion and absorption of feed will be reduced and bird performance and welfare will be compromised.

Figure 2: The faecal dropping (left) should form a semi solid bolus comprising of waste material with a white uric acid cap – this should be checked for abnormalities such as excessive water, fat, mucus and feed particles. The caecal dropping



Figure 3: Electron micrograph of villi (left) and microvilli (right) of the small intestine



Gut Inhabitants – A World to Discover

The community of microorganisms in the gut is referred to in many ways: friendly bacteria, gut flora, gut microbiota and gut microbiome. It is a diverse community of mainly bacteria, fungi, protozoa, and viruses. Modern DNA-based technologies have given a much more accurate picture of the bacterial species present in the gut it has become increasingly evident that a large number of bacteria in the gut are currently unknown and unclassified. Recent studies focusing on poultry have proposed that the gastrointestinal (GI) tract of a bird is colonised by an estimated 600-800 species of bacteria. The abundance and diversity of the microbiota varies along the GI tract and, predictably, the regions which have less tolerable conditions and faster passage of gut contents have lower numbers of bacteria. Even though bacteria can be found in the gut of the developing embryo, it is generally considered that the development of the adult gut microbiota predominantly begins on hatching where bacteria are picked up from the environment, the feed, and the people handling the poults post-hatch. The crop is rapidly colonised within 24 hours. After one day post-hatch the ileum and caeca are also both dominated by bacteria. After three days the level of bacteria in the small and large intestine increases ten-fold. The first bacteria to enter the gastrointestinal tract can be considered the pioneering bacteria as they rapidly multiply and colonise the gut environment. The composition of the pioneering bacterial community goes through a succession of changes as the gut develops and oxygen levels fall. It can take up to 8-12 weeks for the microbiota to form the climax (or adult) microbiota, but during this period stability is seen in the gut if poults are provided with optimal brooding conditions along with good feed and water quality.

Key management points

The gut consists of a diverse range of bacteria, fungi protozoa and viruses. Development of the gut microbiota begins on hatching; bacteria are picked up from the environment, the feed and people. Each of these 3 areas can affect gut microbiota development.

The crop harbours a large population of lactobacilli. These bacteria partially ferment carbohydrates in the feed and produce lactic acid which reduces the pH of the crop environment. The conditions within the proventriculus are highly acidic creating an environment which is unsuitable for most bacteria. The gizzard also has an acidic environment but has a substantial population of lactobacilli which mainly originate from the crop. The bacterial population of the small intestine is made up of mainly lactobacilli although enterococci, E. coli, eubacteria, clostridia, proprionibacteria, and fusobacteria can sometimes be found.

The bacterial population of the small intestine evolves as the bird ages but will generally be stable by two weeks of age. The caeca provides a more stable environment which allows the colonization of slower growing fermentative bacteria. Early in the life of the poult the caeca are dominated by lactobacilli, coliforms, and enterococci, but by two to three weeks of age the caecal environment will start to stabilise as the adult caecal flora begin to dominate. At this stage the pioneering species are replaced with bacteroides, eubacteria, bifidobacteria, and clostridia.

Role of the Intestinal Microbiota

Within the GI tract there are multiple interactions between the host (bird) cells, the intestinal environment, bacterial cells, and feed components. These interactions emphasise the extremely important role of gut microbiota in the health and well-being of the host (as discussed below) although the exact way in which this is achieved is not yet fully understood. The bacterial community of the intestinal microbiota form a protective barrier which lines the gut preventing the growth of less favourable or pathogenic bacteria such as Salmonella, Campylobacter, and Clostridium perfringens. This principle is most commonly known as competitive exclusion. Theories suggest that the commensal (or friendly) microbiota dominate attachment sites on the gut cells reducing the opportunity for attachment and colonization by pathogens. Another proposed mechanism is that the intestinal microbiota are able to secrete compounds, including volatile fatty acids, organic acids, and natural antimicrobial compounds (known as bacteriocins), that either inhibit the growth of or make the environment unsuitable for less favourable bacteria.

Studies using germ-free animals have also shown that the intestinal microbiota is important in the stimulation and development of the immune system. It is thought that the commensal microbiota maintain the gut immune system in a state of 'alert' so that it can react quickly to pathogens. The gut microbiota is also considered to be an important factor in the development and maturation of the immune system.

Animals lacking a gut microbiota have been shown to be more susceptible to disease and have poorly developed immune tissues. In addition to protection against disease and stimulation of the immune system, the intestinal microbiota can influence host growth rates by producing extra nutrients through the fermentation of the indigestible plant fibres that the birds cannot digest.

The Balance of Gut Health

Gut health relies on the maintenance of the delicate balance between the host, the intestinal microbiota, the intestinal environment, and dietary compounds. This balance can be significantly affected by factors such as bird management, feed quality and the birds' environment. When gut health is optimal there is complete digestion of the feed and absorption of the nutrient components. If there is a disruption to the normal processes in the gut, incomplete digestion and absorption of nutrients can occur leading to mal-absorption and gut imbalance. If there is any imbalance in the gut environment, gut health is then at risk of being compromised which can impact upon the health and performance of the birds. When digestion and absorption is not optimal there is malabsorption of nutrients resulting in more nutrients being available to the small intestinal bacteria which can lead to an overgrowth of the bacterial population. A further consequence of malabsorption is the passing of proteins, sugars, and fat into the caeca causing an overgrowth in the microbial population and a shift away from the beneficial fermentative bacteria.

Key Management Points

- The balance of the microbiota in the gut can be affected by factors such as:
- Poor gut development
- Feed change
- Feed quality and raw materials.
- Mycotoxins
- Biosecurity.
- Environment (temperature and ventilation).
- Brooding conditions.
- Infection (ensure good coccidiosis control and vaccination strategies)
- Water quality

Diet has been found to be the most influential factor on the composition of the gut microbiota. Changes in raw material type, nutrient density and feed form have all been shown to impact upon the microbiota. During the life of a turkey flock there are a number of feed changes where there is a shift in composition of the diets; this invokes a change in the micronutrients available for the gut microbiota. The consequence of this change can be a minor bacterial imbalance in the gut as the microbiota adjusts to the new feed; this imbalance is usually of no consequence unless there are other factors impacting upon gut health at the time of the feed change.

Feed form is very important for gizzard function; excess fines or poor pellet quality can result in the gizzard passing feed into the small intestine too quickly. If this occurs there is not enough time for the acid and pepsin enzyme to break down protein resulting in whole proteins entering the small intestine which is detrimental as the small intestine cannot properly digest whole protein. When this happens there is protein malabsorption and increased viscosity in the gut, both of these increase the risk of dysbacteriosis and in severe cases may lead to necrotic enteritis. The use of cracked corn, whole wheat, grit and oystershell can help with gizzard stimulation to ensure optimal mixing of the feed within the gizzard.

Changes in the bacterial populations of the small intestine and caeca that occur during an imbalance are commonly referred to as dysbacteriosis and if prolonged can have negative effects on the host (see box below). The shift in caecal bacterial activity results in the production of different bacterial metabolites (the compounds produced by bacteria when they break down nutrients). Some of these metabolites, such as amines produced from bacterial metabolism of amino acids, can cause gut irritation making the ongoing gut upset worse.

The presence of certain bacteria increases during dysbacteriosis, and the action of these bacteria further affect nutrient absorption. For example, some bacteria can reduce fat absorption by inactivating the bile acids which bind to dietary fats for absorption. Other bacteria can destroy the surface of the villi reducing the surface area available for nutrient absorption. When nutrient absorption is reduced it is not uncommon for birds to increase their feed intake in an attempt to meet their nutritional demands. This can lead to faster gut transit time, feed passage, and wetter litter.

Key Management Points

Dysbacteriosis is not a specific disease, but a secondary syndrome. It is an imbalance in the gut microbiota as a consequence of an intestinal disruption. It results in poor nutrient absorption in the gut leading to poorer FCR and reduced liveweight. If dysbacteriosis is severe enough it can contribute to wet litter.

The presentation of dysbacteriosis varies depending on severity but it is generally characterised by the production of wet faeces and foamy caecal droppings. Post mortem examination of affected birds reveals thinning of the gut wall along with gassy and watery gut contents.

Dysbacteriosis can result from environmental stress, viral or bacterial challenge, coccidiosis or in response to feed change. Dysbacteriosis can be treated with antimicrobial drugs, however it is preferable to use alternative treatments such as organic acids or probiotics as such as a gut imbalance is suspected.

If the primary cause of the dysbacteriosis is not identified it is likely to reoccur – therefore it is imperative to identify and rectify the cause of the intestinal disruption.

If the gut is properly developed and the immune system is not compromised the impact of a gut upset on bird growth (and FCR) can be reduced. After the birds hatch and get access to feed and water the gut is triggered into its final stages of maturation. Biosecurity, shed hygiene and brooding management are all key for poult health and the establishment of a healthy gut. During the first two weeks of life the gut undergoes rapid maturation with rapid growth of the intestinal villi; the length of the villi after this growth phase is critical as it dictates the length of the villi in the adult bird. If villi growth is compromised during brooding the result is shorter villi in the adult bird which will impact upon performance. Optimal villi growth relies on correct brooding management along with good feed and water quality. In the field it has been observed that the poults receiving good brooding tend to develop a gut that performs well and has a greater capacity to cope with challenges in the turkey shed.

Water quality and line management are critical for the long term health of the gut; failure to monitor and promote water quality on farm can be detrimental to gut health and bird performance. Water management strategies depend upon water source (e.g. mains water or open source water), water hardness, water pH and mineral levels in water. The box below outlines the steps for ensuring the supply of clean water to poults.

Water Quality

General water management protocol

1. Ensure adequate cleaning between flocks
 - Remove biofilm (e.g. 25-50ppm Hydrogen peroxide in water line for 24-72 hours then flush)
 - Remove scale (Target a pH of 5 with weak acid e.g. Citric acid – sit in line for 24 hours then flush)
2. Prior to bird arrival
 - Use bleach solution in standing water
 - Flush just before birds arrive
3. Through life of flock
 - Sanitise (e.g. Chlorine (2-4ppm) or Chlorine dioxide (0.8ppm))
 - Acidify water (pH 5.5-7)
 - Perform waterline biofilm removal at regular intervals through life of flock (Biofilms can form in 6 weeks)
 - Routinely check ORP at the drinker furthest from the water tank to check efficacy of sanitation. (It should be >650 mv)

The colour of the gut surface, the tone of the gut wall, and the consistency of the contents are basic indicators of ongoing gut health and can help with the identification of the cause of the issue (Figure 4).

Figure 4: Indicators of gut health. The image on the left shows a healthy gut with the duodenum at the top then the jejunum and then the ileum. The gut surface is pink with the gut wall folding back on itself indicating good muscular tone. The transition of the content consistency and colour are good indicating good digestion. The images on the right show poor gut health from different birds. Here, the surface of the gut is seen to be inflamed, the gut tone is poor, and the contents consist of mucus and excessive fluid. These are all indicators of poor gut health and impaired digestion.



Gut Health Additives

There are many products available to support gut health, these products can either be added to water, added to the feed at the feed mill or top dressed on feed at the farm. Gut health additives vary in their mode of action which makes choosing the right product difficult. Some gut health products provide or stimulate beneficial bacteria, some promote the development of the gut tissues, some aid digestion and others inhibit pathogens. Consequently when deciding which product to use, it is critical to investigate what is causing the gut health issue and ensure that any potential product has the ability to help solve the issue faced. These products often get called ‘alternatives to antibiotics’ and they are used successfully in programs targeting a reduction in antibiotic use. However, it is important to recognise that their use is more preventative and thus we should consider their use as an ‘alternative strategy’. As part of a strategic approach the aim is to administer a product which offers a solution to the needs of the gut at significant points in the chicken’s life. The gut has three predominant stages; *development, transition and maintenance* (see figure 5). During the development stage the aim is to promote bacterial colonisation, and stimulate tissue and immune development. The transition stage refers to the time periods where there are fluctuations in the gut environment in response to impacting factors such as a feed change, vaccination and handling. These events can cause a change in the intestinal environment and increase the risk of malabsorption and bacterial overgrowth. The maintenance stage refers to the period when the gut has stopped developing and reached balance, however there is still the risk of disruption due to management or pathogen challenges, so it is important to maintain support of the gut tissues.

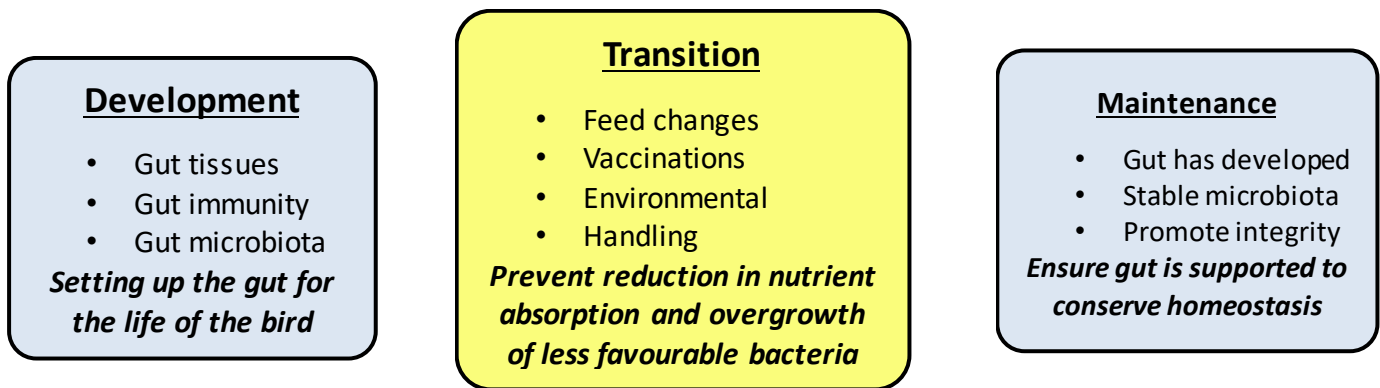


Figure 5: Understanding the needs of the gut at different points in the birds’ life and the main aims gut health support at these times.


Gut Health Research

Gut health provides for an active area of research in both human and animal science. Aviagen Turkeys is committed to gaining a better understanding of gut flora, gut function, and gut immunity by undertaking internal research projects and collaborating with universities to ensure the latest technologies and knowledge are exploited to improve bird gut health in the field.

Conclusions

Maintaining the balance of good gut health is a key aspect of getting the best growth and FCR out of any food producing animal. Many researchers have attempted to understand gut microbiota, gut function, and gut immunity. It is increasingly evident that the gut remains a highly complex area. Regional variations in poultry production, management styles, climate, disease challenge, and feed raw materials add further complexity to maintaining good gut health but what is clear is that developing and maintaining gut health through good bird management practices is key to maintaining bird health, welfare, and performance.

See diagram on next page: Gut Health Factors to Consider.



Gut Health factors to consider

Ventilation

- Fresh air is necessary for bird health, thus proper ventilation is required
- Failure to ventilate can result in a build-up of carbon dioxide, ammonia, and moisture in a shed.
- Wet litter can occur if moisture is not removed from the shed.
- The result can be gut upset and poor footpad health.

Biosecurity

- Poor biosecurity is a threat to any poultry flock.
- Many gut pathogens can accidentally be introduced to a turkey shed.
- This can be reduced by:
 - Foot dips or boot changes between sheds.
 - Vermin control.
 - Keeping wild birds out of the shed and feed.
 - Good storage of feed.
- Limit/prevent exposure to microbes from previous flocks.
- Ensure proper clean-out and disinfection.
- Ensure waterlines and any supplementary drinkers are cleaned and disinfected.
- This reduces the chance of early exposure to pathogens.

Feed

- Feed changes and raw materials will affect the balance of the gut microbiota.
- Poor feed quality will translate into poor FCR as the bird will require more food to meet its metabolic demands.
- Poor gizzard development and stimulation will impact upon gut function and health.
- A diet with more fines will pass through the gizzard quicker, this impacts upon protein digestion and can result in nutrient malabsorption
- Mycotoxins can cause damage to the gut tissues leading to infection or poor efficiency

Periods of High Challenge

- There are events during poultry production where challenges are inevitable:
 - Vaccination.
 - Feed change.
 - Moving birds as with move and brood
- During these periods, the gut microbiota can fluctuate and, in some cases, dysbacteriosis can occur.
- This would be a key opportunity to use a product such as a probiotic to act as a gut stress buffer to maintain gut health.

Temperature

- Incorrect temperature can stress poults.
- Feed intake can also be affected.
- This impairs gut development.
- Result is poor gut function and poor FCR as the bird ages.

Early Gut Health/Brooding

- Key aspect is to boost gut development as much as possible.
- This is an investment in the potential for the ability of the bird to obtain optimal FCR
- Ensure the poults receive appropriate management during brooding.
- Sub-optimal management can impair gut development and the immune system.
- The result is an inefficient gut more susceptible to upset.
- Early feed and water access is essential for gut development
- Delayed access can impair the maturation of the gut tissues and the gut microbiota.

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