Low Protein Diets

- Low protein diets for swine
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Low Protein Diets for Swine
Current State of Understanding and Future Needs

INTRODUCTION

The advent of crystalline amino acids via fermentation has had a pronounced impact on animal nutrition over the past 30 years. With commercialization of each new feed grade amino acid, we as nutritionist are presented a new set of challenges. Commercial feed grade amino acids have provided the opportunity to decrease dietary protein levels, increase our knowledge of basic amino acid nutrition, and feed animal to their dietary requirements.

Low protein diets (LP) have many benefits over traditional high protein (HP) diets. These derived benefits of using LP in conjunction with crystalline amino acids include decrease fecal and urinary nitrogen excretions reducing environmental nitrogen load and positively impacting gut health.

When LP diets are properly formulated to meet the pig's essential amino acid (EAA) requirements; pig growth performance and carcass merit have successfully been maintained. However, as we now have 8 of the 10 EAA available commercially; we are facing new challenges to maintain performance with further reductions in dietary protein levels.

Nitrogen Excretion and GI Health

Intuitively, one could deduce that lowering N intake would obviously decrease N excretion. However, the magnitude of this reduction is nearly 2.8% with each 1% decrease in dietary CP as illustrated in Fig. 1.

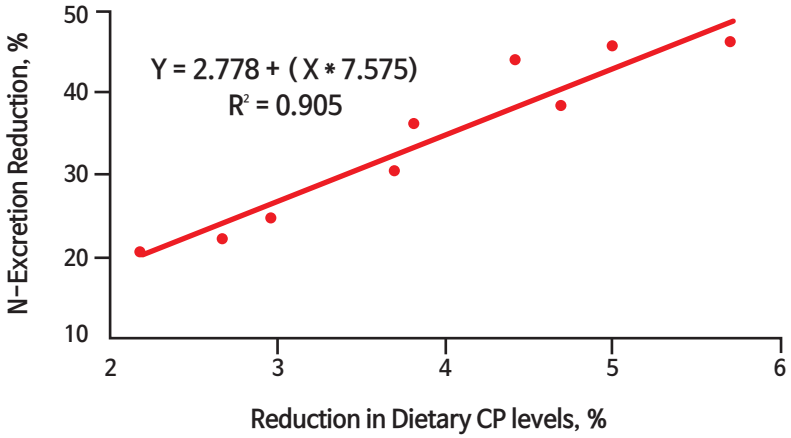

Fig. 1. Impact of Reducing Dietary CP on N-Excretion (Wang et.al., 2019)

Kerr et. al. (2006) demonstrated additional environmental benefit in lowering dietary CP. They observed lower VFA, phenol, indole and N_2O concentrations indicating the production of less offensive odors to human when feeding LP diets.

Reducing CP in the diet of young pigs has been employed by nutritionist since the early 1990's to aid in control of post weaning diarrhea, however, we still struggle in CP reductions of greater than 3% units. Yue and Qiao (2008) lowered dietary CP from 23.1% to 18.9% reported improvements in post weaning diarrhea and improved fecal consistency scores without sacrificing performance. However, a further reduction in CP to 17.2% resulted in lowering animal growth performance in spite of additions of L-Ile, L-Val and L-Phe at suggested ideal protein ratios.

Animal Performance

The replacement of 100 kg of soybean meal (SBM) with 3 kg of L-Lysine (Lys) and 97 kg of corn was widely adopted in the USA in the late 1980's, effectively reducing dietary crude protein (CP) by 2% percentage units. The advent of commercially available L-Threonine (Thr), L- Tryptophan (Trp) and Methionine (Met) in the 1990's allowed for further reduction in dietary protein in swine diets. Adoption of the idea protein concept (Fuller, et. al., 1989 and Chung and Baker, 1992) has allowed for swine nutritionist to confidentially lower dietary CP further. It is generally accepted among swine nutritionist that dietary protein levels can be reduced by 3 to 4% units using the four crystalline AA sources (Lys, Thr, Met and Trp) without sacrificing growth, FCR or carcass merit (Kerr et. al., 2003). However, when dietary protein levels are reduced beyond 4% units, the literature suggest a loss in both ADG and FCR.

Powell et. al. (2011) conducted a series of five growth assays with growing pigs (initially weight of either 21 or 42 kg) fed a positive control (PC) with 18.2% CP or negative control (NC) with 13.3% CP. They added various combinations of both essential AA or non-essential AA to the diets. Interestingly, the additions of Ile, Val and Histidine (His) in combination restored ADG, but not FCR. Addition of Cystine (Cys) to provide a 50:50 ratio to Met did not improve performance, nor the addition of Arginine (Arg) to the Ile, Val and His. Growth performance (ADG) was restored with the additions of ILE, VAL and HIS with 0.224% Glutamine (Glu) added. However, Glu level needed to be increased to 0.52% to restore FCR to the level of the PC.

Gloaguen et. al. (2014) using N-retention as the response criteria, reported no impact of lower dietary CP from 19.7 to 16.8% on N-retention and observed co-committal 29% decreased in N-excretion in weaned pigs (12 -13 kg, initially). Further reduction in dietary CP to either 14 or 12.7% result in lower ($P<0.001$) N-retention. In the second experiment there were successful in maintaining N-retention with a 4% reduction in CP by the additions of L-Val, L-Ile, L-Leu, L-His and L-Phe. Additionally, a SBM-free diet with cereal grains and AA only could provide similar ($P>0.10$) N-retention to a control diet (17.8% CP) when additional amino-N in the form of Glu was provided to increase dietary CP to 14%. This trial demonstrated the importance of having proper EAA/Lys ratios and suggest that nitrogen for NEAA in vivo synthesis maybe limiting in LP diets.

The Kansas State University Swine Nutrition team has extensively evaluated the minimum CP levels needed for late finishing pigs (109 to 127 kg). J.A. Soto (2016[1,2], 2018) conducted a series of growth followed by carcass trials to examine the impact of CP in late finishing pigs.
In all experiments ADG, FCR or HCW were optimize at a minimum of 12%. The team evaluated the addition of other nutrient components of SBM (choline, potassium) nor dietary electrolyte balance and could not restore performance to the 12% CP level.

Recently, Mansilla et. al. (2017[1]) reported that ADG and FCR could be restored to positive control levels with the addition of ammonia citrate, Glu or a mixture of NEAA. In their follow up study (Mansilla et. al., 2017[2]) they examined the additions of either ammonia (NH_3) or NEAA mixture (formulated to whole body NEAA profile) in a 8.01% CP diet formulated to be adequate in EAA. Carcass and whole body N-retention was increased ($P<0.05$) with dietary addition of either NH_3 or the NEAA mixture. However, carcass AA profile was not impacted ($P>0.10$) by N source.

These studies suggest there is a minimum level of non-specific nitrogen which is required to maintain animal performance and carcass merit when feeding very LP diets. It also, suggests that the nitrogen can be in non-amino form. With the commercial availability of feed grade branch chain amino acids (BCAA) Val and Ile; re-examination of the BCAA ratio to Lys have begun to be conducted. Liu et. al. (2015) re-examined the Val/Lys ratio in pigs from 23 to 120 kg. They reported that the Val/Lys increased with increasing BW (Broken line: 62 -68, Quadratic 68-72).

One of the confounding, but importance aspects in examining BCAA to Lys ratio is the dietary Leu level. Htoo et. al (2017) work clearly demonstrates that the optimal BCAA ratio to Lys is depended on the dietary Leu concentration. This is of particular importance when using corn by-product such as DDGs, corn gluten feed or corn gluten meal. CJ America sponsored study (Zier-Rush, et. al., 2018) to recalibrate the Ile/Lys ratio in late finishing pigs(70 to 102 kg). They reported that maximum ADG and FCR in late finishing pigs is achieved with elevated ratios of Ile to Lys at 60% compared to currently recommended levels (55 to 56%) in a corn-SBM EAA fortified diet. Current research under way is recalibrating His/Lys ratios (Cemin, et. al., 2018). Initial work from this group suggest in 7 to 11 kg pig, the required ratio is 31% which is similar to the original estimates from Chung and Baker (1992). Other USA swine integrators are also re-evaluating His/Lys ratios in weanling and growing pigs preparing for cost effective feed grade Ile and Val to price into feed formulations.

Summary

Over the past 30 years, tremendous strides have occurred in swine amino acid nutrition. We now can routinely feed 3 to 4% lower crude protein diets throughout the globe. However, with each additional feed grade amino acid entering the market poses a new set of challenges and opportunities to refine AA requirements and ratio.

The current literature suggest we have some serious gaps in our knowledge as it pertains to further reductions in dietary CP levels. The current data conclusively suggest that there is a minimum CP needed to maintain animal performance. This dilemma has four main possible explanations:

1. We need further refinement of our empirical EAA/Lys ratios at various life stages for both the pig and broiler;
2. Some non-essential AA such as Tyrosine, Glycine, Serine, Glu or other AA maybe semi-essential or limiting in low CP diets;
3. There is a minimum level of non-specific N required to maintain necessary biochemical processes or;
4. The use of high AA fortified diets may potentially increase interactions or antagonisms between AA.

CJ America - Bio is actively working with leading universities and large poultry and swine integrators to understand how we use the new feed-grade Val and Ile in commercial diets to reduce feed cost and maintain optimal health and animal performance.

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by

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Amino Acid Nutrition Update to Ensure Successful Low Protein Diets

INTRODUCTION

The current level of protein used in livestock diets has produced various issues occurred in the feed industry including feed cost and feed efficiency, health and animal welfare, environmental pollution, and even environment protection tax. More and more people are concentrating on the benefits of low protein diets and making more efforts to get the success of low protein diets with use of feed additives.

There are many benefits of low protein diets, such as saving feed cost, increase in feed utilization, improvement of body health and animal welfare, and protecting environment.

In order to achieve the widespread use of lower protein diets in the feed factory, the use of ideal amino acid ratios with crystalline amino acid supplements will contribute to the investigation of lower protein diets. Supplementation of crystalline essential amino acids such as L-lysine, L-methionine, L-threonine, L-tryptophan, L-valine and L-arginine to balance the digestible amino acids in diets could maintain the performance of livestock fed lower protein diets.

The benefits of low protein diets

Save feed cost

The current CP level used in the feed industry contributes to higher feed cost. As the livestock prices especially pork price decrease sharply, the nutritionists want to save all the unnecessary costs. Therefore, setting-up the real nutritional requirements for animals is necessary. It is very important to evaluate the digestible amino acid contents of raw material. Protein meals contain wide range of AA while crystalline AA are used to meet specific AA requirement of livestock. Soybean meal is the most widely used protein source in the feed industry due to its ideal nutrient characteristics. China had import soybean meal 7.2 Billion MT from U.S., Argentina and Brazil. Digestible AA model to make the formula could save feed cost.

In addition, the increasing availability of specialty feed grade

amino acids such as Valine, Tryptophan and Arginine has made lower crude protein diets very easy and feasible.

We talked about decreasing crude protein of diets, not about decreasing the nutrition contents. We just need to make our formula more precise. The ideal protein is the most practical tool to express the amino acid requirements of animals. All ideal amino acids are expressed in ratio to Lys. By formulating each limiting amino acid profile, the protein level will be adjusted automatically with least cost. We had accumulated experience on how to set the Threonine and Methionine ratio to Lysine. The Tryptophan ratio to Lysine has become more and more clearly.

Valine requirement recently updates very quickly. Estimated Val requirements are of 76-80% (SID)Val:Lys depending on the growth performance criteria of broiler, 68-70% (SID) Val:Lys for piglets, and 95-105% (SID)Val:Lys for lactation sow. In terms of Arg, estimated Arg requirements are of 110-115% (SID)Arg:Lys depending on the growth performance criteria of broiler, 100-110% (SID)Arg:Lys for piglets, and 110-120% (SID)Arg:Lys for pregnancy and lactation sow.

In the present situation, if we decrease crude protein level from 22% to 21% in broiler feed and balance the 5th limited amino acid, the feed cost will decrease nearly 2%.
A famous enterprise company has been a big success on decrease in crude protein level in pig feeds, it made formula as 12% crude protein level in finishing pig feeds.
The company said that this technical method could save 64 RMB/Herd in the feed cost of raising farm.

Increase feed utilization

Excess CP can overload the intestinal tract with excessive undigested protein, and even will cause diarrhea. Excess AAs presented in the diet are absorbed and catabolized, producing higher levels of N excretion in the form of uric acid (Wu, 2013). As undigested proteins exit in the intestine tract and increase the bacterial proliferation, they can cause disease and infection, and will further reduce production performance. Improved feed utilization can be achieved by reducing N retention. Reducing dietary CP can improve N utilization.

Improve livestock health and protect environment

Reducing crude protein in diets can decrease the risk of disease and improve animal welfare. N wastes have become a focus of environmental sustainability due to their impacts on water pollution and ecosystems (Sims and wolf, 1994). Reducing dietary CP further promotes the sustainability and marketability of the poultry industry. Improving industry sustainability with low protein diets comes from reducing water intake and N excretion (Belloir et al., 2017).

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An Important Approach during Heat-Stress Condition in Broilers

INTRODUCTION

Nutrition for broilers under high temperature is extremely important for the livestock industry in the tropics, because of the significant decrease in feed intake and consequent effect on overall production performance. Heat stress is one of the most important factors affecting the animal production traits such as carcass quality, feed efficiency, growth rate and most especially, mortality. A lot of intervention strategies are being considered to reduce the heat stress increment of the livestocks by either nutritional (feed additive addition, high levels of oil and other raw materials with low heat increment) or technological (tunnel ventilated housing facility, sprinkling and shading) means (Lara et al., 2013).

Recently, other innovative approaches have been explored, one of which is lowering the crude protein (CP) of the diet and considering other essential amino acids, aside from tryptophan, which include Methionine and Arginine. It is well known that animals reduce feed intake under heat stress conditions, thus, it is very important that even with low feed intake, the animals would be able to get the necessary nutrients that they need from highly digestible and absorbable sources. Compared to carbohydrates and fats, protein has the highest heat increment and the negative effects of of high-protein diets on mortality rate may be associated with increased heat production, resulted from an increase in protein catabolism (Ghasemi et al., 2013).

Amino Acid Supplementation during Heat Stress Condition

It is very important to consider that the animals under heat stress condition has lower amino acid digestibility. According to Furlan et al. (2004), broiler chickens under heat stress during the growing phase had reduced rate of arginine absorption, which suggests that the ideal arginine to lysine ratio should be higher for broilers during summer. In addition, Zarate et al. (2003) evaluated a commercial diet with and without essential amino acid supplementation (10% over commercial levels) in

broiler chicken raised during summer, and concluded that amino acid supplementation had a limited effect on heat production and increasing the percentage of EAA and the balance within dietary CP can improve the proportion of productive energy recovered from metabolizable energy (ME).

Methionine

L-methionine supplementation to diets with lower reduction rate or short-term reduction of protein and amino acids is a promising strategy to maintain performance and to improve health indices and heat tolerance in broilers exposed to heat stress during summer (Ghasemi et al. 2013). Methionine is the first limiting amino acid in poultry that plays an essential role in metabolism. Furthermore, methinonine has various physiological functions including antioxidant effect, heat stress reduction, fatty liver inhibition and liver detoxification. The use of L-methionine saves 19.048 kcal/mol energy of D-methionine, which could help lower heat increment and instead save the energy for meat deposition and other production paremeters.

Arginine

L-arginine, a basic amino acid, is an important AA for chickens because birds are unable to obtain arginine from endogenous sources since they lack almost all the enzymes that are involved in the urea cycle (Fouad et al., 2012). Arginine serves a number of important biological and physiological functions in poultry such as improvement in immune response, reduction of total body fat, anti-oxidant, improvement in bone quality parameters and heat stress reduction. Heat-stressed chickens exhibit higher production of reactive oxygen species and higher level of peroxidation that led to oxidative damage to chicken muscle (Fouad et al., 2012). Furthermore, Fouad et al. (2012) reported that L-arginine supplementation significantly enhanced total antioxidant capacity and production of nitric oxide, which is responsible for the dilation of the blood vessels, and significantly declined the level of lipid peroxidation and regulate thermoregulation.

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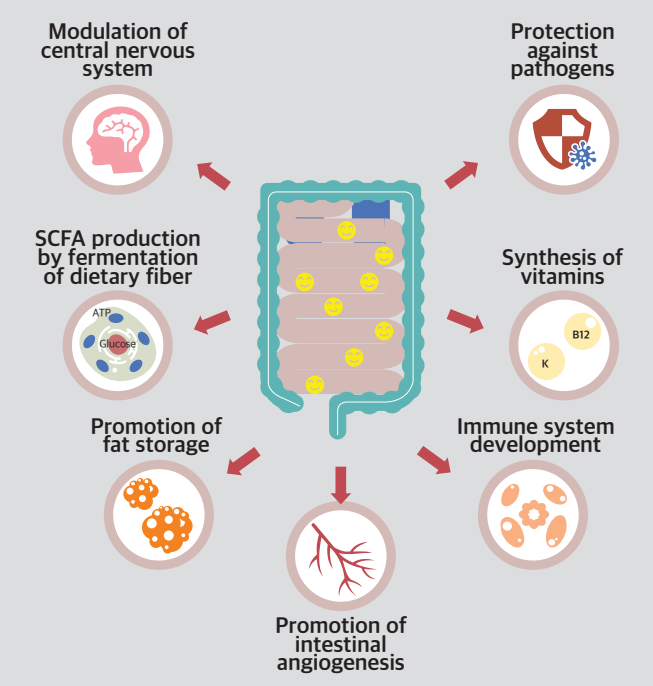
Why low protein diet is so important for your gut health?

A healthy human starts with a healthy gut. Microbes in your body play an important role in your health.
Interest of the microbiome in human health has recently increased. The protein digestion plays a key role in determining the microbiota. Especially, there is growing recognition of the role of dietary protein in modulating the composition and the metabolic activity of the gut microbiota is increasing.

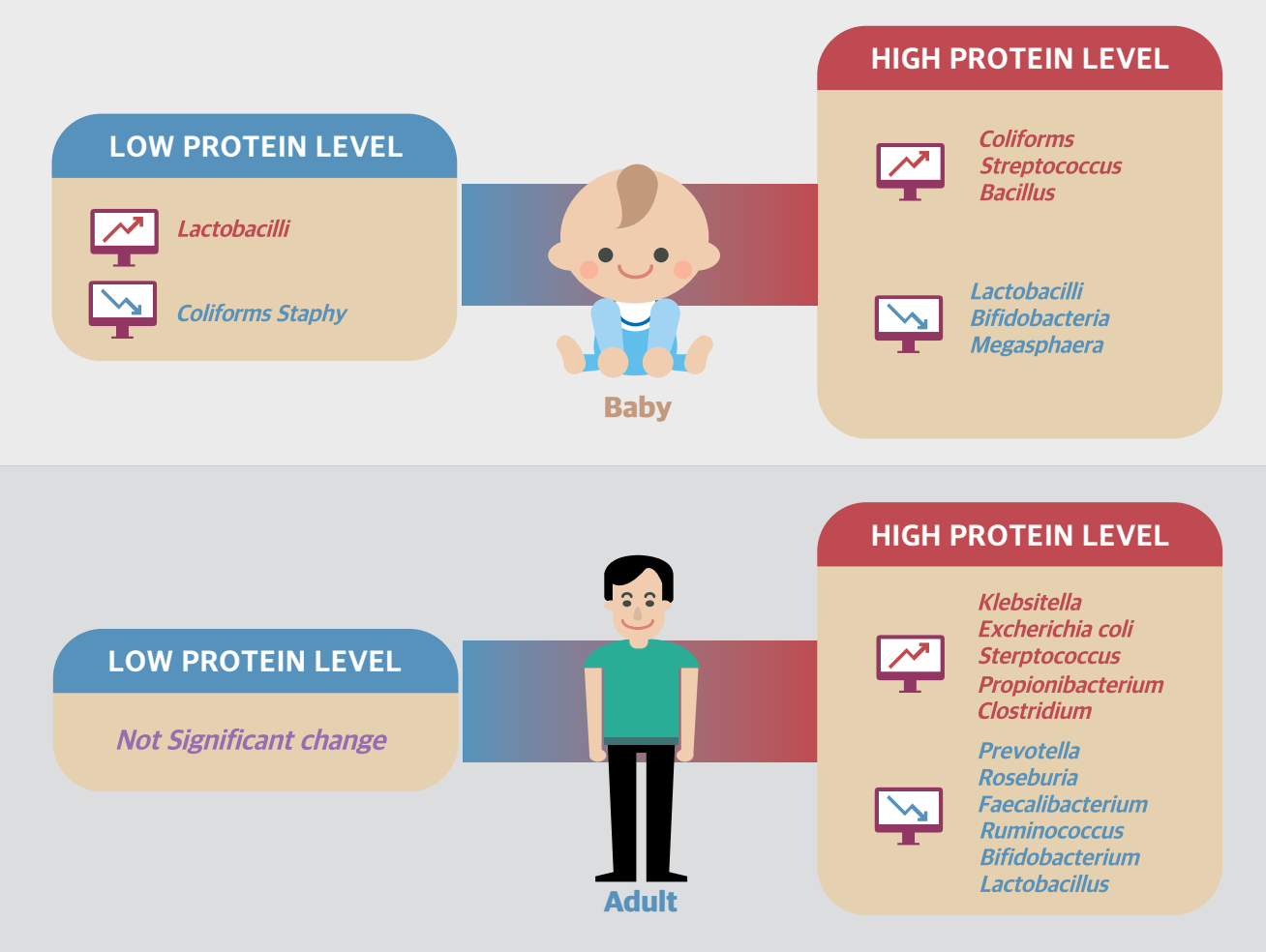
What is the microbiome?

All animals have unique collection of microbes in digestive tracts, collectively known as the gut microbiome. The human microbiome (the genome of all our microbes) consists of the 100 trillion microbes. Bacteria in the microbiome help digest food, regulate the immune system, and protect against pathogens. They play an important role in digestion of nutrient. Imbalance in the body's bacteria can cause digestive disorders, allergies, diabetes, anxiety, and depression. Maintaining a proper balance by altering diet components is critical role in preventing the growth of pathogenic bacteria.
The human microbiome plays a vital role in control of the homeostatic mechanisms in the body, such as resistance to infection and inflammation, prevention against autoimmunity.



Contributions of the interaction between dietary protein and gut microbiota to intestinal health

Intestinal microbiota plays a very important role in your health by helping control digestion and immune system. The ecosystem of the gastrointestinal tract microbiome is largely affected by dietary factors. Especially dietary proteins provide amino acids to the host. The amino acid composition and protein digestion determine the microbiota. Changes of microbiota can affect the intestinal barrier and the immune system.



In newly weaned animals, the abundance of probiotics such as *Lactobacilli* increased whereas the population of pathogens such as *Coliforms* and *Staphylococci* decreased. In adult animals, the change of microbial composition is observed only when the protein level changes greatly. Protein-fermenting bacteria, such as *Escherichia coli* and Bacteroides increased whereas saccharolytic bacteria, such as *Bifidobacterium,* and *Lactobacillus* decreased. Dietary protein is an essential nutrient for animal growth and is considered a crucial factor in regulating gut microbiota of monogastric animals. A low-protein diet inhibits the proliferation of pathogenic bacteria and reduces the number of potentially pathogenic bacteria such as *E.coli.* Thus, a low protein diet improves gastrointestinal tract health in all animals. Attention to the diet strategies with protein supplementation is necessary to benefit your gut health.

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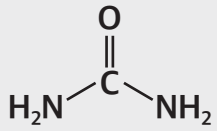
Nitrogen waste in bird

Excess nitrogen caused by excess consumption of protein must be excreted from the body. Nitrogenous wastes tend to form toxic ammonia which requires energy in the form of ATP and a large quantity of water to dilute and excrete it out of biological system. All terrestrial animals must detoxify ammonia by converting it into a less toxic form such as urea or uric acid. Mammals including humans depend on the formation of urea through urea cycle to get rid of it from body. Unlike mammals, birds have evolved the ability to convert toxic ammonia into uric acid instead of urea. Uricotelic organisms tend to excrete uric acid waste in the form of a white paste or powder. The conversion of ammonia into uric acid needs more energy than into urea. Birds get some advantages from converting ammonia to uric acid rather than to urea because uric acid is less toxic and helps birds be able to reduce water loss and subsequent need for water.

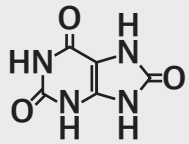
Urea and uric acid

UREA (Mammals)



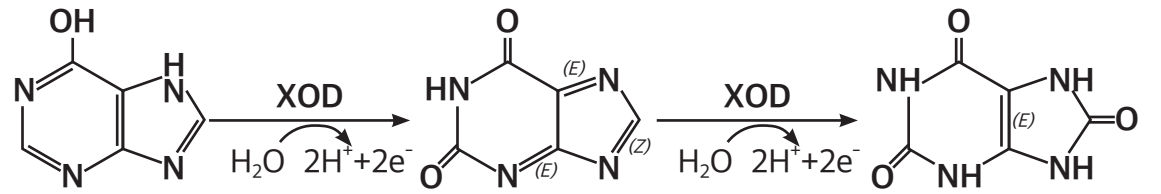
- Simple Molecule
- Less Expensive to Synthesize
- Less Nitrogen per Molecule
- High Water Soluble

URIC ACID (Birds)



- Complex Molecule
- More Expensive to Synthesize
- More Nitrogen per Molecule
- Low Water Soluble

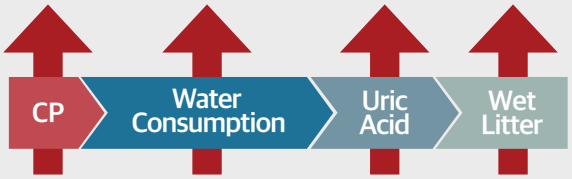
Transformation of xanthine to uric acid



Hypoxanthine → Xanthine → Uric acid + H_2O_2 + O_2^-

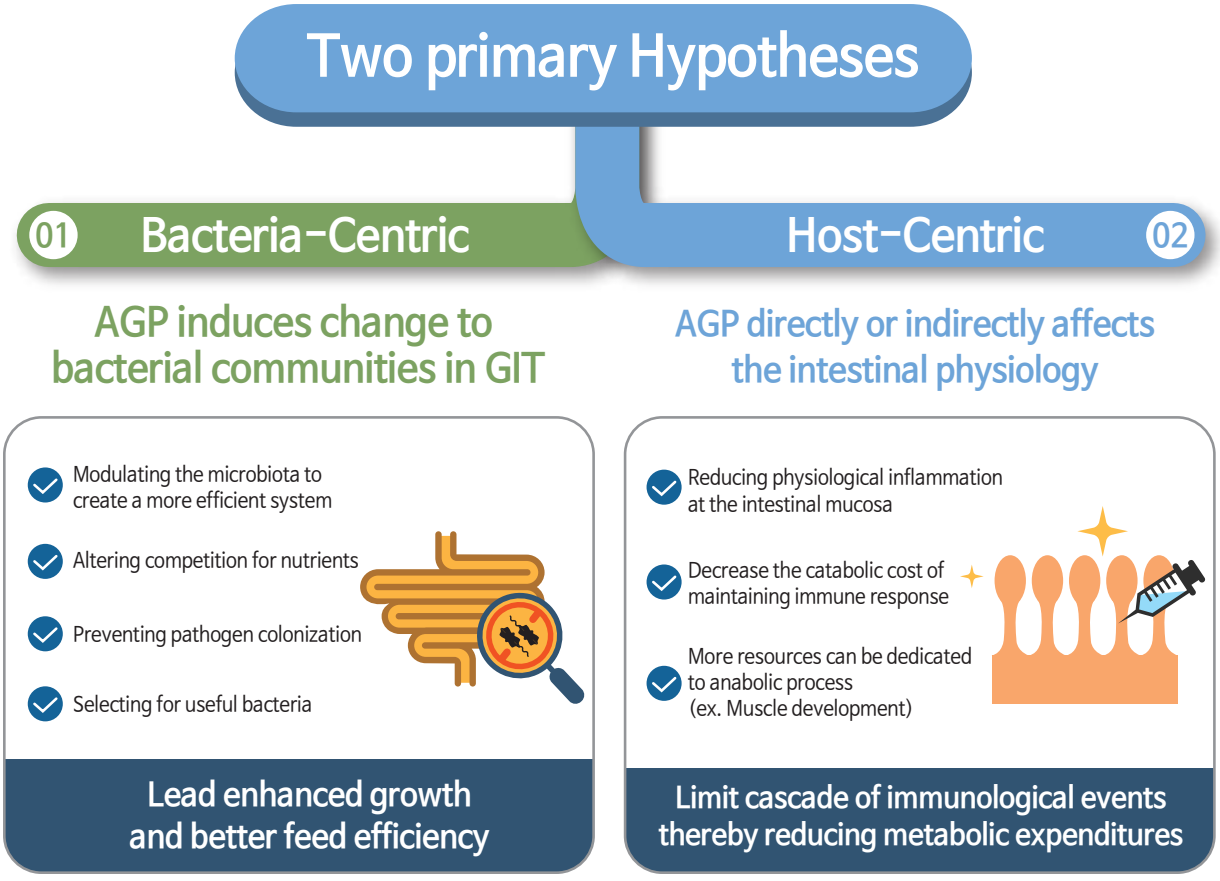
- Xanthine + $2O_2$ + H_2O ⟺ Uric acid + $2O_2^-$ + $2H^+$
- Xanthine + O_2 + H_2O ⟺ Uric acid + H_2O_2
- Xanthine + NAD^+ + H_2O ⟺ Uric acid + NADH + H^+

1. Water (H_2O) is needed to form Uric Acid
2. Uric Acid excreted with water
3. The higher CP consumption, the more water excretion
4. 1% CP reduction in diet can reduce 3% of water consumption
5. Increasing water excretion can lead wet litter problem



The mechanism of AGP

Source: Thomas P. et al, 2017



As a result of the increasing global demand for animal proteins, the use of antimicrobials in livestock is of considerable concern due to the threat of antimicrobial resistance (AMR). The use of antimicrobials in animals is associated with drug-resistant infections in animals and humans. In September 2016, the United Nations (UN) General Assembly recognized the inappropriate use of antimicrobials in animals as a leading cause of rising AMR. The ban on the use of antibiotics in food animal business has become a megatrend around the world and now all of us needs to be prepared for it.