Why anti-nutritional factors are harmful to *young animal health*

Anti-nutritional factors in soy protein pose a risk to young animal health. Hamlet Protein aims to minimize the factors that are most critical to the growth and development of piglets, chicks and calves.



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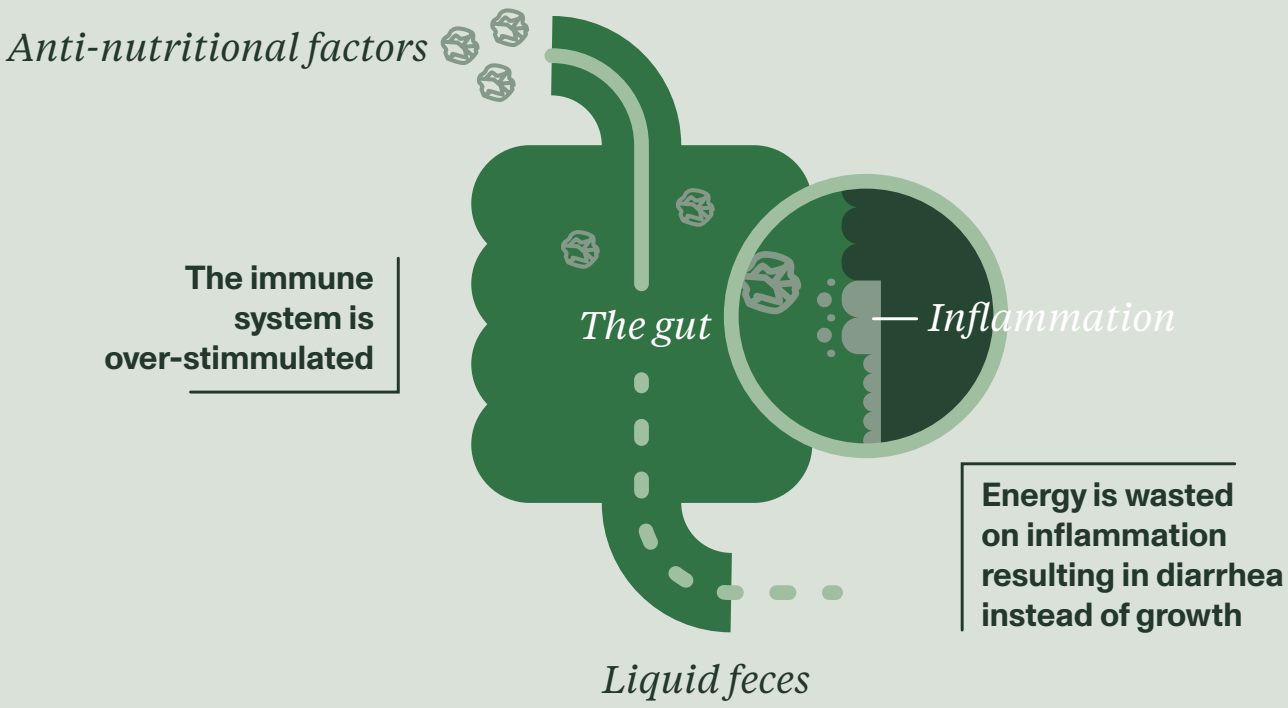
Soybeans – *an excellent protein source, but...*

Soybean meal (SBM) is universally recognized as one of the few sources of plant-based protein that contains all the essential amino acids necessary to animal growth and development. Yet, when standard SBM is used in starter feed, young animals have a hard time digesting and absorbing many of these vital nutrients. Soy's natural content of anti-nutritional factors (ANFs) is the reason.

In soybeans, ANFs cover a range of substances that provide important protection against mold, bacteria and over-consumption by wild animals. In feed for piglets, calves and chicks, they represent a health risk. Many scientific studies have documented their harmful effect on the development and functionality of the gut, reducing the utilization of nutrients and compromising growth.

The effect of anti-nutritional factors on the gut in young animals



Removing the problem

The obvious way to overcome this challenge is to minimize the ANF content of the soy in young animal feed. Heat treatment by toasting, extrusion or steaming is widely used. But there are drawbacks when excessive heat is applied. Protein denaturation results in loss of nutritional value, and the Maillard reaction – when reducing sugars and amino acids form irreversible complex bindings – leads to a further reduction in amino acid utilization.

Although it is possible to avoid such problems by applying a moderate heat treatment of maximum 110°C for 30 minutes (Mathai & Stein, 2018) this is not sufficient to inactivate all ANFs. Additional advanced enzymatic treatment is necessary to reduce ANFs to a tolerable level so young animals can digest the soy proteins in their feed and gain full nutritional benefit, avoiding potential health issues.

At Hamlet Protein, we have identified the ANFs that are least tolerated by piglets, chicks and calves and, as such, are most critical to their health and development. Our patented process is designed to inactivate these ANFs gently and effectively to optimize the availability of the essential amino acids in our specialty soy proteins.



Our patented process is fine-tuned to minimize the ANFs critical to young animal health. These are the primary targets:

Oligosaccharides
Stachyose and raffinose are the oligosaccharides in focus. In the immature guts of young animals, the absence of galactosidase enzymes means there is no capacity to break these carbohydrates down. They then pass to the large intestine where they are fermented by bacteria, causing abdominal discomfort, flatulence and wet feces. Oligosaccharides cannot be eliminated by heat treatment.

Trypsin inhibitors
These proteins form complex bindings to the digestive enzymes trypsin and chymotrypsin, inhibiting their ability to break down the soy proteins in starter feed. As young animal guts secrete enzymes at too low concentrations to counter trypsin inhibitor activity, this provides potential pathogens with an abundant supply of non-digested protein to ferment. Toxins produced by the fermentation process damage the gut lining and may permeate the gut, activating the immune system. Trypsin inhibitors can be removed by heat treatment.

Antigens
Beta-conglycinin is the soy antigen that poses the biggest challenge in young animal feed.

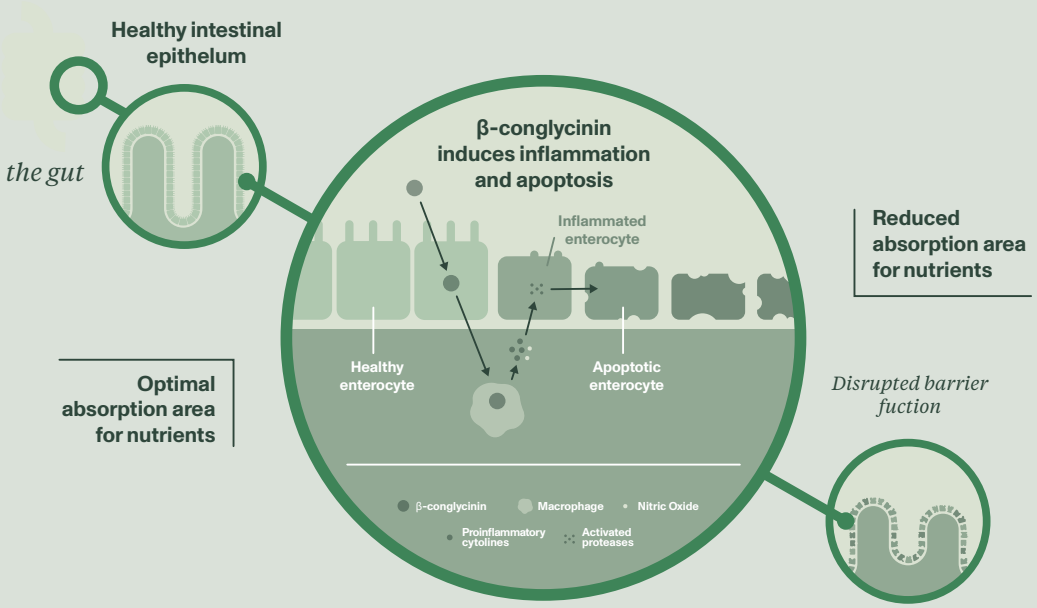
Along with glycinin, it comprises the greatest part of the protein in raw soybeans. In a mature animal gut, beta-conglycinin is broken down by trypsin and pancreatic proteases. In a young animal, however, the common outcome is an allergic reaction, leading to oxidative stress and inflammation.

Beta-conglycinin cannot be fully removed by heat treatment.
Potential health problems include the following:

– *Villi atrophy and increased gut permeability*
As a response to beta-conglycinin exposure, macrophages in the gut lining produce proinflammatory cytokines which inhibit the growth of intestinal cells and destroy cell structure. Apoptosis (controlled cell death) and villi atrophy (which reduces the gut's capacity for nutrient absorption) occur. Increased gut permeability has been observed, allowing toxins and other large molecules to cross the gut membrane and cause an allergic reaction.

– *Scouring/wet litter*
Nearly 90% of the neurotransmitter serotonin is stored alongside the epithelial cells that line the gut and regulate the peristaltic movements, whereby feed is transported through the gut. When an allergic reaction occurs, the epithelial cells are damaged, releasing the neurotransmitter. This increases the strength and rate of peristaltic movements, contributing to scouring.

– *Oxidative stress linked with inflammation*
Specific proteins in animal cells regulate the immune response to infection. When activated by beta-conglycinin, the production of proinflammatory cytokines goes up, activating the neutrophils – white blood cells – that promote oxidative stress. This triggers a vicious cycle of inflammation that becomes chronic if beta-conglycinin remains in the diet. Antioxidants, such as vitamin E and C, and micro-minerals are often added to feed to compensate for oxidative stress.



ANFs critical *to piglet health*

The formulation of piglet feed has come into sharper focus as authorities around the world have imposed more restrictions on the use of antibiotics and zinc oxide. This has brought an even greater need to minimize diet-related health risks and ensure full utilization of the nutrient content.

The challenge is that, up to the age of seven to eight weeks, piglet guts lack a fully developed enzymatic system and have limited digestive capacity. For this reason, piglets are dependent on easily digestible and high quality protein in their feed to support organ and muscle development. Diets that fail to meet these nutritional requirements will compromise this development and cause a slowdown in growth that is never recovered.

Oligosaccharides, trypsin inhibitors and antigens are the critical ANFs to avoid in a soy-based piglet starter feed.

Oligosaccharides in soy protein are fermented by bacteria in the small intestine as the necessary enzymes are not available to break them down. Gas produced by the fermentation process causes flatulence. Those oligosaccharides that are not fermented have an osmotic effect that draws water from the gut lining, speeding up gut transit time and leading to scouring.

Trypsin inhibitors restrict the digestibility of protein, which then passes unabsorbed into the colon without contributing to animal growth. In the colon, undigested protein is fermented by bacteria, including potential pathogens, which produce toxic end-products that impair the integrity and functions of the intestinal membrane. Toxins absorbed from the gut activate the immune system, which requires energy to combat the toxins. In this way, there is less energy available for piglet growth, resulting in lower performance.

Antigens have a negative impact on the gut membrane, causing inflammatory lesions and compromising the gut's ability to absorb nutrients. Negative effects include increased mucus production, intestinal villi atrophy and cellular apoptosis. Another consequence of a compromised, more permeable gut is that large and potentially harmful molecules can pass the gut lining and cause an allergic reaction. The subsequent activation of the immune system draws on energy and nutrients, reducing the resources available to support piglet growth. Recent research indicates that the greater the exposure to antigens, the greater the impact on piglet health.



ANFs critical *to chick health*

The influence of soy ANFs on chick health is attracting growing attention. This follows the rise of restrictions on antibiotic use in countries around the world, which has caused diet-related health issues to become increasingly apparent.

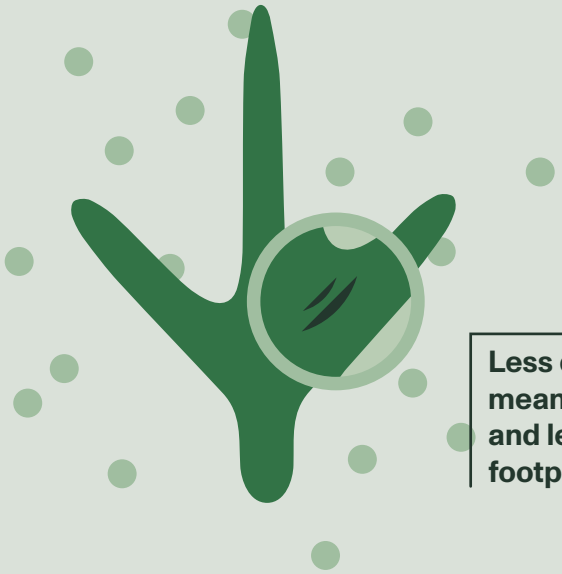
Until now, the ANFs of key concern have been trypsin inhibitors and oligosaccharides. However, the antigen beta-conglycinin is now also believed to be a possible health issue that may cause inflammation of the gut lining, wet litter and reduced nutrient uptake and growth.

Trypsin inhibitors are particularly critical in young chicks during the first four days of life when their immature guts produce very few digestive enzymes. Due to the significant impact on protein digestibility, this leaves plenty of undigested protein available for fermentation by pathogenic bacteria. The toxins produced by the pathogens damage the gut lining and may contribute to the development of necrotic enteritis – the major intestinal infection in chickens.

Oligosaccharides travel undigested from the chick small intestine. They are then partially fermented by the immature microbiota in the large intestine and ceca. Non-fermented oligosaccharides have an osmotic effect that releases water from the gut lining, contributing to a fast gut transit time and wet litter and increasing the risk of footpad dermatitis



Low content of soy ANFs in chicken starter feed results in less diarrhea



Less diarrhea means fewer and less seroius footpad lesions

ANFs critical *to calf health*

Calf performance is most at risk in the first eight to ten weeks of life, before the transition to ruminant is complete. At this stage, calves are still functional mono-gastrics with few digestive enzymes and, as such, a limited ability to absorb nutrients in feed. Growing international restrictions on the use of antibiotics in calf starter feed mean there is now a greater need to focus on diet-related health risks, such as ANFs in standard SBM.

Antigens and trypsin inhibitors are the primary ANFs in soy-based pre-starter feed that create health and performance issues for young calves after weaning.

Antigens pose the greatest health risk. Calves do not tolerate high concentrations of the soy antigen beta-conglycinin, in particular, and develop antibodies against them. This results in damage to the villi in the small intestine, a shorter gut transit time and frequent scouring, with reduced nutrient uptake and lower weight gain to follow.

Trypsin inhibitors limit the enzyme activity that breaks down soy protein – a compounding factor in immature calf guts where enzyme availability is already low. Undigested protein can then serve as substrate for potentially pathogenic bacteria, increasing the risk of scouring and poor overall health.



Low incidence of scouring and villi atrophy when **Hamlet Protein** *products are included in pre-starter feeds*



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