Tryptophan is an essential amino acid in pigs, which means that the diet is the only way to supply tryptophan to the animal. Tryptophan is after lysine, methionine plus cysteine and threonine the fourth limiting amino acid in cereal-based diets for piglets and growing pigs under practical conditions. It is, like the other essential amino acids, an important substrate for protein synthesis in the body. When the supply of tryptophan via the diet (relative to the other essential amino acids) is limiting, protein synthesis is compromised and performance is decreased.

**APPETITE REGULATION**

Besides the production of muscle proteins, tryptophan is involved in different biological functions. One of the most important is the involvement in the regulation of feed intake. In fact, tryptophan is the precursor of the neuromediator serotonin known to play a central role in appetite regulation\(^1\). Recent studies have also shown that tryptophan infusion and dietary level of tryptophan could modify ghrelin plasma concentration and its expression in gastric fundus and duodenum\(^2\). Ghrelin is a hormone involved in nutrient intake. In addition to its involvement in feed intake, tryptophan metabolism is involved in inflammatory response\(^3\).

**EFFECTS IN DIFFERENT DIETS**

Tryptophan requirement was recently studied in young piglets using two diets differing in ingredient composition\(^4\). A diet deficient in tryptophan based on maize/soybean meal, and a diet deficient in tryptophan based on wheat, barley, soybean meal, peas and whey powder were formulated. Both diets were calculated to contain 1.5 g/kg standardised ileal digestible tryptophan. Both basal diets were supplemented with 0.3, 0.6 and 0.9 g/kg diet free L-tryptophan to obtain diets with 1.8, 2.1 and 2.4 g/kg standardised ileal digestible tryptophan, respectively.

The results are presented in Table 1. Over the complete experimental period (0–4 weeks), body weight gain and feed conversion ratio were significantly affected by the nature of the diet (maize/soya vs. wheat/barley) and during the past decades, the interest in the essential amino acid tryptophan has steadily increased, especially in piglets because they are particularly sensitive to tryptophan. However, how much does the animal actually require in terms of diet, age, health and sanitary housing conditions? This article presents an update on tryptophan requirements in piglets and its factors of variation.
TABLE 1 - EFFECT OF DIET COMPOSITION (MISOY/BEAN MEAL) VS. A DIET BASED ON WHEAT, BARLEY, SOYA BEAN MEAL, PEAS AND WHEAT FLOUR (VW/V) AND Tryptophan CONTENT ON THE PERFORMANCE OF PIGLETS PER 0.5 g/kg STANDARDISED ILEAL DIGESTIBLE TRYPTOPHAN SUPPLEMENTATION (0-24 KG BW).

<table>
<thead>
<tr>
<th>Diet Composition</th>
<th>Feed ingredient</th>
<th>Digestible Tryptophan (mg/kg)</th>
<th>Feed conversion ratio</th>
<th>Body weight gain (g/d)</th>
<th>Feed intake (g/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MISOY/BEAN</td>
<td>1.5</td>
<td>1.52</td>
<td>1.51</td>
<td>386</td>
<td>203</td>
</tr>
<tr>
<td>VW/V</td>
<td>2.0</td>
<td>1.49</td>
<td>1.48</td>
<td>409</td>
<td>223</td>
</tr>
<tr>
<td>VW/V</td>
<td>2.5</td>
<td>1.66</td>
<td>1.65</td>
<td>452</td>
<td>253</td>
</tr>
</tbody>
</table>

**CLEAR RESPONSE**

It was concluded from the study that in both types of diets there was a clear response of feed intake and body weight gain on supplementation with L-Tryptophan. The requirement for tryptophan in young piglets seemed slightly higher in diets based on maize/soybean than in a diet based on wheat/barley. Generally, at the same level of standardised ileal digestible tryptophan in the diet, performance was higher for the piglets fed the wheat/barley based diet compared to piglets receiving the maize/soya based diet. The highest absolute body weight gain was obtained when the diets contained 2.4 g/kg  standardised ileal digestible tryptophan per kg diet (equivalent to 1.5 g/kg standardised ileal digestible basis).

**Tryptophan and Dietary Protein Level**

Tryptophan plays a role as a precursor of the serotonin-transporter serotonin and the epidermal hormone melanin. In this way its tryptophan and dietary proteins could have an effect on feed intake, sleeping-waking rhythm, behaviour and immune system. The transport of tryptophan through cell membranes (at intestinal and brain level) competes with the transport of the large neutral amino acids (LNAA), being the branched chain amino acids (BCAA; valine, leucine, isoleucine), phenylalanine and tyrosine. As a result, the ratio between LNAA and tryptophan in the blood plasma plays a role in the serotonin synthesis in the hypothalamus in the brain. Serotonin (5-hydroxytryptamin, 5-HT) plays an important role in the regulation of feed intake. Diet rich in protein generally reduce the availability of tryptophan for serotonin synthesis. Moreover, it has been found in many tryptophan requirement studies that the use of diets deficient in tryptophan results in a marked reduction in feed intake. Hence, it is concluded from the study that the level of tryptophan in the diet is important for the availability of protein in the diet, which is also important for the regulation of feed intake. DJAMAN et al. (2000) further studied the interaction between the level of BCAA and tryptophan in the diet on the performance of young piglets. Two basal levels of tryptophan deficient diets with 1.6 g/kg standardised ileal digestible tryptophan were used. Two levels of tryptophan supplementation (2.0 and 2.4 g/kg standardised ileal digestible tryptophan in the diet) were evaluated. Increasing the level of tryptophan in the diet significantly increased body weight gain numerically up to 20.5 and 847, respectively. It was concluded from this study that the content of 2.4 g/kg standardised ileal digestible tryptophan in the diet with a high tryptophan to BCAA ratio and body weight gain was highest for the group receiving the maize/soya based diet. The highest absolute body weight gain was obtained when the diets contained 2.4 g/kg standardised ileal digestible tryptophan per kg diet (equivalent to 1.5 g/kg standardised ileal digestible basis). Furthermore, the body weight gain was highest for the group receiving the diet with a high tryptophan to BCAA ratio and body weight gain was significantly improved for the treatments with 1.8, 2.1 and 2.4 g/kg standardised ileal digestible tryptophan, compared to the treatment with 1.5 g/kg standardised ileal digestible tryptophan. For the treatments on the wheat/barley diet, feed conversion ratio was significantly improved for the treatments with 1.8 and 2.4 g/kg standardised ileal digestible tryptophan compared to the treatment with 1.5 g/kg standardised ileal digestible tryptophan.

**HEALTH AND SANITARY CONDITION**

In pigs, studies showed that inflammation induced tryptophan metabolism disturbances. Chronic lung inflammation was associated with a decrease in tryptophan plasma concentrations compared to pair-fed healthy piglets (Figure 1). One explanation can be an increase in tryptophan catabolism through the kynurenine pathway by the enzyme IDO (indoleamine 2,3 dioxygenase). In fact, pigs suffering from lung inflammation had higher IDO activity in lungs and associated lymph nodes than pair-fed healthy control piglets. In other species, the depletion of free plasma tryptophan has been associated with increased tryptophan degradation under IDO activation occurring in various inflammatory states, since the enzyme IDO is stimulated by pro-inflammatory cytokines, especially interferon-γ. A second hypothesis corresponds with the incorporation of tryptophan in proteins with high tryptophan content, such as acute phase proteins synthesized during inflammatory response.

The induction of an IDO pathway has been proposed to be a mechanism that limits the availability of tryptophan during an inflammatory process and may play a crucial role in the regulation of the immune and inflammatory responses. In pigs, it was shown that the level of dietary tryptophan was able to influence the inflammatory response (Figure 2). Indeed, pigs suffering from lung inflammation had a lower plasma haptoglobin concentration when they were fed a diet balanced with tryptophan (1.4 g/kg) compared to pigs fed a low tryptophan diet (0.3 g/kg). Haptoglobin is a major acute phase protein used as an indicator of inflammation in pigs. The activity of IDO measured in the lungs and associated lymph nodes was also lower when the dietary supply of tryptophan was adequate. Moreover, lung inflammation was associated with a decrease in feed intake and growth performance.

**References**

1. Dr Alfons Jansman graduated from Wageningen University in The Netherlands and obtained his PhD at the same university in 1985. Since 1986 he has been working as senior scientist and cluster manager of the Animal Sciences Group (port of Wageningen.UI) in Lelystad, the Netherlands. His main areas of expertise are the nutritional value of feed ingredients, digestive physiology in pigs, immune responses and metabolism, and nutrition and health in pigs. 

2. Delphine Gautier graduated from Agronomie in Paris, France, where she received a PhD in animal nutrition on the subject “Changes in amino acid utilisation in response to chronic lung inflammation in pigs: the case of tryptophan”. She has held the position of area development manager of Ajinomoto Europe S.A., since 2004. Delphine’s area of research are amino acid requirement in swine and poultry.
lesions examined at slaughter were less severe when pigs were fed with a well-balanced control diet. These results suggest that the inflammatory response was reduced when the supply of tryptophan via the diet was adequate. The consequences of the inflammatory and immune responses on tryptophan metabolism could impair the availability of tryptophan for body protein accretion, growth and all other metabolic processes involving this amino acid. In that way, the deterioration of sanitary housing environment after weaning induced a moderate inflammatory response and modified tryptophan metabolism in piglets. These responses were characterised by reduced growth rate, higher plasma haptoglobin and lower plasma tryptophan concentrations compared to control piglets kept in good sanitary conditions. A reduced growth rate was still observed when control piglets were pair-fed with those reared in poor sanitary conditions. The difference in growth rate as affected by sanitary status can therefore be attributed to modifications of nutrient metabolism. Concerning the response of plasma tryptophan, the pigs kept in poor sanitary conditions displayed lower plasma tryptophan concentrations than control piglets independent of the level of dietary tryptophan. Moreover, increased dietary tryptophan did not fully prevent the consequences of sanitary status deterioration on performance. Nevertheless, the growth rate of piglets kept in poor sanitary conditions was more sensitive to low dietary tryptophan than that of control pigs. As a consequence, the improvement of growth rate induced by increased dietary tryptophan content is higher for pigs submitted to a moderate inflammatory challenge caused by poor sanitary conditions (Figure 3). This confirmed that the quality of the environment can be considered as an important factor affecting the tryptophan requirement.

**GENERAL CONCLUSION**

Health status and dietary crude protein level are factors of variation for tryptophan requirement. Independent on the type of cereals used in the diet, a ratio tryptophan to lysine at 2.2% (on a standardised ileal digestible basis) allows optimisation of piglet performance. During the piglet period, feed intake and health are two key factors to consider to achieve optimal performance. This shows the importance of maintaining adequate dietary tryptophan supply during this period. 

References 1-13 are available on request.
poultry.