Tryptophan is an essential amino acid which is the fourth limiting amino acid in European diets for pigs. The determination of tryptophan requirement is essential to optimise growth particularly in piglets where the amino acids requirements are maximum and where protein content of the diet should be reduced as much as possible. As well as its role in protein deposition, tryptophan is implicated in various metabolic pathways such as the production of the neurohormones serotonin and melatonin which are involved in appetite regulation. Additionally, tryptophan metabolism is also implicated with the immune response. This diversity of tryptophan metabolism pathways deserves particular attention in assessing the tryptophan requirement and its factors of variations in young pigs. Especially, in practical conditions, where maximising feed consumption remains an important challenge and where the quality of the environment in which pigs are housed may impact upon the nutrient requirements.

In this context, the present bulletin reviews the tryptophan requirement for optimum growth performance of young pigs between 7 and 30 kg. Also, it emphasises the relationship between dietary tryptophan and feed intake. Finally, a focus is made on tryptophan metabolism related to immune system and the potential consequences this has on the tryptophan requirement for growth of pigs.
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Dietary tryptophan to enhance piglets performance

1.1 Zootechnical response to dietary tryptophan content

The compilation of tryptophan requirement studies in piglets presented in this bulletin is based on a previous compilation of trials already published in Ajinomoto Eurolysine Information n°23 which has been updated with more recent trials.

The experimental design and the composition of the experimental diets are summarised respectively in Tables 1 and 2 (see appendixes p17). In every trial, the dietary tryptophan content was increased from a basal diet with graded levels of L-tryptophan. Because of the variation in absolute level of performance due to weight ranges, genotypes, experimental conditions, and in order to identify the response to increased tryptophan to lysine ratio throughout these trials, the results were expressed on a relative scale, i.e. in percentage of the best performance observed within each trial.

The compilation allows us to draw a model curve to describe the effect of the tryptophan to lysine ratio on piglets weight gain, feed intake and feed efficiency. The addition of new trials to our previous report on tryptophan requirements for piglets (bulletin n°23) confirms that optimum performances (feed intake, growth and feed efficiency) are reached on average with a ratio Trp:Lys of 22% ileal standardised digestible (SID) (Figures 1, 2 and 3).

Figures 1, 2 and 3: Effect of the ratio Trp:Lys SID (ileal standardised digestible) on feed intake, weight gain and feed conversion ratio (relative to best response within each trial) in piglets from 7 to 30 kg

1. Feed Intake, % best performance within each trial

2. Weight gain, % best performance within each trial

3. Feed conversion ratio, % best performance within each trial
Increasing the Trp:Lys ratio from 18% to 22% SID results in an increase in piglet weight gain by 9% and a decrease in feed conversion by 3% (Figure 4).

Practically, it means a shorter piglet growing period and/or heavier piglets. As an example, piglets gaining originally 450 grams of weight per day could reach 25 kg from 8 kg within 35 days instead of 38 days.

1.2 Main part of the effect of tryptophan on weight gain is obtained through an increase in feed intake

Dietary tryptophan content has a greater impact upon growth rate than feed conversion ratio which suggests that part of the effect of tryptophan on growth is obtained through enhancement of feed intake. In order to test this contribution, an experiment was performed by Eder et al. (2001) in pigs in a weight range from 7 to 20 kg. Two types of diet were provided to three groups of piglets: a tryptophan deficient diet with 1.5 g of tryptophan per kg and a diet balanced in tryptophan containing 2.6 g/kg.

The tryptophan deficient diet was provided to the piglets ad libitum. The diet with 2.6 g of tryptophan per kg was either provided ad libitum or as pair-fed rations based on the feed intake of the group fed the deficient tryptophan diet in order to test the specific effect of dietary tryptophan on feed intake.

Ad libitum feeding with 2.6 g tryptophan per kg feed produces clearly superior growth performance than ad libitum feeding of the rations with 1.5 g tryptophan per kg feed. On average, body weight gain, feed intake and feed efficiency are respectively 57%, 43% and 9% higher in the group fed ad libitum with 2.6 g tryptophan per kg feed compared with the group fed ad libitum with 1.5 g tryptophan per kg feed (Figure 5).

In the pair-fed group, feeding the rations with a high tryptophan content does not lead to significantly higher body weight gains than feeding the rations with a low tryptophan content. This trial demonstrates that the growth depression which occurs in tryptophan deficiency is mainly due to the reduction in feed intake (Figure 5).

**Tryptophan requirement to optimise growth**

**Conclusions:**
For piglets between 7 and 30 kg, a ratio Trp:Lys 22% SID optimises weight gain, feed intake and feed efficiency.

**Implications:**
Increasing the ratio Trp:Lys from 18% up to 22% SID, weight gain is improved by 9% and feed efficiency by 3%.
A study investigated the dietary tryptophan requirement in 48 fed ad libitum weaned cross-bred piglets (7.2 ± 1 kg). The pigs were housed in individual pens in a fully air-conditioned experimental piggery. This trial was conducted both in pre-starter period (7 to 15 kg weight) and starter period (15 to 26 kg weight). For each period, a basal diet was formulated:

- **prestarter diet**: 5% skim milk powder, corn, corn gluten feed, peas, soybean meal extract, wheat, molasses (18.8% CP, 13.4 MJ ME/kg, 1.13% lysine total)
- **starter diet**: corn, corn gluten feed, peas, soybean meal extract, wheat, barley, molasses (17.8% CP, 13.4 MJ ME/kg, 1.06% lysine total).

Starting with a basal diet tryptophan concentrations were increased by adding L-tryptophan. Animals were allotted to five dietary groups according to a complete randomised block design.

In the pre-starter period, daily gain and daily feed intake increase in a linear manner. Best performance is obtained for the highest level of tryptophan in the diet which represents a ratio Trp:Lys 23% SID (Figure 6a). In the starter period, daily gain and feed intake are optimised for a ratio Trp:Lys 21% SID (Figure 6b).

### INFO 1
**Optimal Trp:Lys ratio in piglets**

*(Roth et al, 2005)*

**Aim of the trial**: Optimal Trp:Lys ratio in piglets between 7 and 25 kg.

**Results**: A ratio Trp: Lys 22% SID is optimal for growth and feed intake.

In this trial, the association of the responses in pre-starter and starter on a relative scale shows that increasing the ratio Trp:Lys through L-tryptophan supplementation allows to optimise weight gain and feed intake with a ratio Trp:Lys even higher than 22% (Figure 7).

In addition, the figure 7 suggests that for a ratio Trp:Lys above 19%, the effect of the ratio Trp:Lys is obtained mainly through an increase in feed intake since above that level feed intake and weight gain curves follow the same pattern.
2 Tryptophan: a key nutrient in the regulation of feed intake

Feed intake is an essential driving force for growth of piglets, especially in the post weaning period. In a number of studies including piglets (Sève et al, 1991), growing pigs (Henry et al, 1996, Eder et al, 2003), finishing pigs (Henry and Sève, 1992) and lactating sows (Pampuch et al, 2004), an inadequate supply of tryptophan resulted in a markedly reduced feed intake.

It is known that compared with other amino acid deficiency (lysine, threonine, methionine, isoleucine), tryptophan deficiency will most severely depress feed intake. Tryptophan has a particular status regarding feed intake because it is the precursor of the neurotransmitter serotonin which is involved in the regulation of satiation and appetite.

2.1 Dietary tryptophan and brain serotonin

A compilation of studies shows that in pigs, an increase in tryptophan content in the diet induces a very clear increase in serotonin (5-HT) concentration in various parts of the brain. However, the increase is variable among tissues and is not always linear (Figure 8).

In young pigs, Pastuszewska et al, (2005) shows a net increase in serotonin concentration in different parts of the brain such as the hypothalamus, area preoptica or striatum when tryptophan content in the diet is raised from 1.18 g/kg to 1.80 g/kg of diet.

Further increase of tryptophan concentration in the diet from 1.80 g/kg to 2.26 g/kg does not necessarily lead to increased content of serotonin in the brain (Figure 8) despite the fact that feed intake is still enhanced. Greater tryptophan supply in the diet may impact upon not only brain serotonin content but also serotonin turn over in the brain. Consequently, above a threshold further increase in dietary tryptophan may improve serotonin utilisation and in turn appetite regulation.

This hypothesis is supported by Pastuszewska et al, (2005) who measured an increased concentration of serotonin metabolite 5-hydroxy-indole-3-acetic acid (5-HIAA) and of the 5-HIAA/serotonin ratio in four of six brain structures when dietary tryptophan was increased above 1.80 g/kg.

Figure 8: Response of brain serotonin (5-HT) in pigs to dietary tryptophan in % of the highest level within a tissue : A (Pastuszewska et al, 2005); B (Henry et al, 1996), C (Sève et al, 1991)
2.2 Competition between tryptophan and other amino acids for the transportation through the blood brain barrier

The amount of plasma large neutral amino acids (LNAA, namely phenylalanine, tyrosine, isoleucine, valine, and leucine) is highly correlated to dietary crude protein (CP). LNAA are inhibitory competitors of tryptophan for transportation through the blood brain barrier, therefore excess amounts of LNAA in the blood may decrease the production of serotonin.

Practically, the depressive effects of tryptophan deficiency on feed intake and growth is accentuated by excess protein and particularly by large neutral amino acids (LNAA) (Henry et al, 1992; Henry et al, 1996; Jansman et al, 2000).

In piglets, Jansman et al, (2000) showed that decreasing the crude protein content of the diet led to a better optimisation of the feed intake and weight gain in response to L-tryptophan addition in the diet (Figure 9). Indeed the decrease in CP level from 20% to 17% is consistent with an increase in ratio Trp:LNAA SID.

Figure 9: Piglet feed intake and weight gain as influenced by the ratio Trp:Lys (ileal standardised digestible basis) and dietary protein level (Jansman et al, 2000)
2.3 Other hypotheses

Serotonin is not only synthesised in the brain but also in the gastro-intestinal tract (GIT). It is possible therefore that some effects on voluntary feed intake may come from peripheral tissue where the competition between Trp and LNAA may also occur (Henry et al., 1996).

Another hormone called melatonin can be produced from serotonin. At any given time, the gastrointestinal tract contains at least 400 times more melatonin than the pineal gland (Huether, 1993). Plasma levels of melatonin as well as GIT tissue levels can rise in response to feeding in pigs (Bubenik et al., 1996). In addition, melatonin was found to influence peristalsis. According to Bubenik et al. (1996), it can be speculated that the increase in melatonin levels after the intake of food may serve as a signal for the regulation of appetite, or for the synchronization of the feeding and digestion processes.

Additionally, Sève et al., (1999) reported that gastric emptying is significantly enhanced in pigs fed with a tryptophan adequate diet (0.26% total of the diet) compared with a tryptophan deficient diet (0.16% total of the diet).

These results suggest that the tryptophan effect on feed intake, whether it is through serotonin, melatonin or others, may not only be located in the brain.

Tryptophan: a key nutrient in the regulation of feed intake

Conclusions:
- Serotonin is involved in appetite regulation and its content in the brain is related to dietary tryptophan intake.
- Serotonin production is conditioned by the proportion of tryptophan to large neutral amino acids and to dietary crude protein.

Implications:
Feeding a piglet diet low in protein and high in tryptophan content is a relevant way to optimise feed intake and consequently growth.
Ettle and Roth, (2004) aimed to investigate whether piglets could recognize and select diets varying in tryptophan content and whether this preference changes with time. Two groups of piglets were offered two diets containing either 0.11 or 0.16% of tryptophan (Trp-choice 1), or 0.11 or 0.20% of tryptophan (Trp-choice 2). In addition, two reference groups were fed either 0.11 % tryptophan (Trp-deficient) or 0.20% tryptophan (Trp-supplemented) diets. The position of the two diets of the Trp-choice groups was changed in the feeders twice per week.

The uptake of the diet with 0.11% Trp decreases progressively over the time course of the trial whatever the Trp-choice 1 or 2 (Figure 10 a et b).

For piglets from the Trp-choice 2 group which have been eating mainly the diet with 0.20% of Trp, the total feed intake during the 6 weeks of experiment is significantly higher (22.84 kg) than piglets from the group Trp-choice 1 which have been mainly eating the diet with 0.16% of Trp (13.56 kg) (Figure 11).

Compared with Trp-deficient, increasing tryptophan content of the diets increases feed intake numerically by 9% in Trp-choice 1 and by 75 and 93% in Trp-choice 2 and Trp-supplemented respectively (Figure 12). Final body weight, total weight gain, and average daily gain increases when the ingested amount of tryptophan increases (Figure 12).

**INFO 2**

**Tryptophan and diet selection by piglets**

*(Ettle and Roth, 2004)*

**Aim of the trial:** To determine whether piglets are able to choose between diets varying in tryptophan content.

**Results:**
- When given the choice, piglets can select a diet with higher tryptophan content
- Increasing dietary tryptophan content leads to higher feed intake and faster growth.

**Figures 10a; 10b and 11:** Weekly evolution of piglets consumption (10) and total consumption (11) the 2 offered diets in Trp-choice 1 and Trp-choice 2.

**Figure 12:** Daily weight gain and daily feed intake of piglets in Trp deficient group, Trp-choice 1, Trp-choice 2 and L-Trp supplemented control group.
INFO 3 The effect of tryptophan on feed intake is also reported in lactating sows

(Pampuch et al, 2003)

Aim of the trial: Effect of dietary Trp content in lactating sows performance

Results: • Increasing Trp content of the diet improves feed intake and reduces weight loss in lactating sows • Like in piglets, there is a direct relation between tryptophan content of the diet and feed intake in lactating sows.

Piglets are not the only animals in which feed intake is limiting performance. The effect of dietary tryptophan content on the performance of lactating sows was assessed in a trial conducted in Germany by Pampuch et al, (2003). Sixty one multiparous sows (German Landrace) were tested over a total of 72 lactations lasting 28 days each.

On day 110 of gestation, sows were distributed to six treatments differing by L-tryptophan supplementation resulting in true ileal digestible tryptophan in the diet ranging from 0.9 g/kg to 3.9 g/kg. The basal lactation diet was composed of corn, corn gluten, peas, dried sugar beet pulp, soybean meal, potato protein powder and amino acids and contained CP 15.6%; SID Lys 0.88%; 13.2 MJ ME/kg. The sows were allowed ad libitum access to the diets and the average litter size was standardised with 10 to 12 piglets.

This trial shows that increasing ileal standardised digestible tryptophan concentrations in the diet from 0.9 to 2.1 g/kg feed divides weight loss by 3 and increases 2 times feed intake (Figure 13).

In parallel, the difference in blood serum serotonin between day 28 of lactation and day 85 of gestation is significantly impacted by tryptophan content of the diet.

Increasing ileal standardised digestible tryptophan levels from 0.9 g/kg to 2.1 g/kg prevents a decrease in blood serum serotonin between gestation and lactation (Figure 14) which may explain at least part of the effect of dietary tryptophan on feed intake.
3 Tryptophan and health status

3.1 The relation between amino acids nutrition and health

When health status deteriorates, the decrease in feed intake and the diversion of nutrients from muscles towards immune function modifies amino acid requirements.

Permanent exposure of animals to infectious or non-infectious antigens prevents animals from expressing their growth potential. When pigs are exposed to high antigen pressure, growth and feed intake are depressed even if pigs are not displaying serious clinical signs of disease.

During the life span of a pig, various situations are known to compromise the animal's health: e.g. weaning, moving from one building to another or subclinical infection. The body's response to antigen stimulation is characterised by a combination of actions of cytokines and hormones that induce metabolic changes. Those changes include hyperthermia, a decrease in feed intake, an increase in muscle protein breakdown and protein synthesis in the liver (Klasing and Johnston, 1991; Grimble et al., 1992). Hence, nutrients are diverted away from growth towards the tissues and cells involved in immune functions (Figure 15).

In such a situation, amino acids can be used as an energy source for gluconeogenesis, immune cell proliferation and serve as building blocks for inflammatory protein and immunoglobulin synthesis. Finally, amino acids can enter specific metabolic pathways related to body defence. When the immune system is stimulated, its amino acid consumption is not always balanced by the supply and this could result in specific amino acid requirements. By understanding the interactions between nutrition and immune response, nutritionists and producers can design feeding strategies to maximise productivity while minimising the impact of immune system solicitation.

Figure 15: The detrimental effect of health deterioration on growth is mediated through a decrease in feed intake and the diversion of nutrients from muscles towards immune functions.

3.2 The effect of challenging health on tryptophan metabolism

Plasma amino acid concentration can be used as an indicator of amino acid metabolism because it is the resultant of different metabolic fluxes. Some fluxes bring amino acid in the plasma pool (proteolysis, feed intake) whereas others withdraw them from the plasma pool (degradation, protein synthesis).
In order to assess amino acids whose metabolism is affected by a chronic immune challenge, plasma amino acid concentration of pigs with chronic lung inflammation have been compared with healthy control piglets maintained at exactly the same levels of feed intake during a 10 days experimental period (Melchior et al, 2004). Chronic lung inflammation was induced by intravenous injection of complete Freund adjuvant. Piglets were fed with standard pre-starter and starter diets.

In this trial, among all the essential amino acids, tryptophan is the only amino acid whose plasma concentrations is significantly decreased by the inflammatory challenge (Table 3).

Also it is the only amino acid whose plasma concentration decreases throughout the experimental period without ever reaching the level of control pair-fed piglets (Figures 16 a and 16 b). Table 3:

<table>
<thead>
<tr>
<th>Essential amino acids</th>
<th>Inflammatory challenge</th>
<th>P-value*</th>
<th>effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lysine</td>
<td>0.4</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Methionine</td>
<td>0.9</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Threonine</td>
<td>0.9</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Leucine</td>
<td>0.1</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Valine</td>
<td>0.6</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Isoleucine</td>
<td>0.3</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Phenylalanin</td>
<td>0.3</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td><strong>Tryptophan</strong></td>
<td><strong>0.002</strong></td>
<td>Decrease</td>
<td></td>
</tr>
<tr>
<td>Histidine</td>
<td>0.04</td>
<td>Increase</td>
<td></td>
</tr>
<tr>
<td>Arginine</td>
<td>0.08</td>
<td>–</td>
<td></td>
</tr>
</tbody>
</table>

* P-value < 0.05 means the effect is significant

Figure 16 a et b: Time course of plasma tryptophan concentrations in fasted (a) and fed (b) pigs with chronic lung inflammation or pair-fed healthy control pigs (Melchior et al, 2004)

Taking into account that feed intake is controlled and protein catabolism is mostly accelerated during inflammation, this result suggests an increase in tryptophan use during chronic lung inflammation. Moreover, the same team measured plasma tryptophan in pigs reared in different environments (Le Floc’h et al, 2005). They showed that lowering the sanitary status of pigs housed in a dirty room and by withdrawing antibiotics from the feed also has a significant negative impact on plasma tryptophan concentration. Furthermore Yoo et al, (1997) without controlling piglets feed intake showed that weaned pigs intraperitoneally injected with Escherichia coli have lower plasma tryptophan than healthy controls pigs.

These experiments suggest that plasma tryptophan is affected by the stimulation of the immune system and not only because of a decrease in feed intake.

When health is impacted, the decrease in plasma tyrptophan could be explained at least by two hypotheses: the synthesis of acute phase protein which are tryptophan rich proteins (Reeds et al, 1994) and by the degradation of tryptophan into kynurenine through the induction of indoleamine 2,3 dioxygenase (IDO) activity (Melchior et al, 2004 a, b). IDO has a wide localisation in the body and is specifically induced by immune system mediators such as Interferon-γ. In such a situation, it is responsible for an increased degradation of tryptophan into the kynurenine pathway.
3.3 Effect of a tryptophan deficient diet on inflammatory response

If tryptophan use is increased during immune system stimulation, the question should be asked whether tryptophan has a specific role in inflammatory and immune responses. In order to investigate this possibility, the effect of a tryptophan dietary deficiency has been tested on inflammation response of piglets suffering from induced chronic lung inflammation (Melchior et al, 2004).

In this experiment, the authors compared different indicators of inflammatory response in pigs with chronic lung inflammation fed with a tryptophan deficient diet (1.47 g/kg feed) and in pigs fed with the same diet supplemented with L-tryptophan (2.02 g/kg feed). The inflammation indicators are rectal temperatures, lung weight and plasma haptoglobin concentration. Haptoglobin is a major acute phase protein in pigs.

Inflammation induces an increase in all these parameters. However, lung weight and rectal temperature are significantly lower in piglets fed with the L-tryptophan supplemented diet compared with piglets fed with the tryptophan deficient diet (Table 4).

<table>
<thead>
<tr>
<th>Inflammation indicators</th>
<th>Challenged</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lungs weight/piglets weight, g/kg</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>Average rectal temperature, °C</td>
<td>38.9</td>
<td>39.3</td>
</tr>
</tbody>
</table>

For plasma haptoglobin concentration, the interaction tryptophan x time is significant. Among piglets with inflammation, at the beginning of the experimental period, plasma haptoglobin concentration response is similar in pigs fed with the tryptophan deficient or tryptophan supplemented diets. However, at the end of the second week of the experiment, plasma haptoglobin is significantly lower in pigs fed adequate tryptophan diet compared with tryptophan deficient pigs. IDO activity in lungs is also affected by treatments. The increase in IDO activity in piglets with lung inflammation is lower in piglets fed the tryptophan adequate diet compared to tryptophan deficient piglets. Moreover, lung lesions at slaughter are also less severe in L-tryptophan supplemented pigs.

Finally, Pigs suffering from chronic lung inflammation have lower signs of inflammation when fed the tryptophan adequate diet. In addition, in this experiment, it is shown that an adequate tryptophan dietary supply helps pigs submitted to lung inflammation to maintain their plasma tryptophan concentration (Figure 17).

Figure 17: Plasma tryptophan concentrations in pigs with chronic lung inflammation fed a tryptophan deficient diet (challenged L-Trp -) or a tryptophan adequate diet (challenged L-Trp +) and in control healthy pig fed a tryptophan deficient diet (control L-Trp -).

These results may have important practical implications. In fact, when the immune system is activated even moderately, the disappearance of tryptophan from plasma may limit its availability for growth. Consequently, tryptophan supply should be adequate in order to cover the total requirement for the immune system if activated but also to maintain growth performance (see INFO 4, Le Floc’h et al, 2005).
An experiment was conducted by Le Floc’h et al., (2005) to compare the effect of tryptophan supplementation on growth in pigs reared in differing environmental conditions. The composition of the prestarter (body weight 8 to 12 kg) and starter (body weight 12 to 27 kg) diets is shown in Table 5.

Twenty blocks of four littermate piglets were allocated to one of the four treatments resulting from 2 x 2 factorial design. Two levels of dietary tryptophan were applied: low (Total Trp:Lys 19% and 17% respectively for the first and second period postweaning) or supplemented (Total Trp:Lys 22% and 21% respectively in the first and second period postweaning) (Table 5). Also, two levels of sanitary status were tested: high (clean room and antibiotics in the diet) and low (dirty room and no antibiotics in the diet).

Table 5: Composition and main nutritional value of the tryptophan deficient (L-Trp-) and tryptophan supplemented diets (L-Trp+) for piglets from 0 to 19 days postweaning (8-12 kg) and from 20 to 50 days postweaning (12-27 kg) (Le Floc’h et al, 2005)

<table>
<thead>
<tr>
<th></th>
<th>8-12 kg</th>
<th>12-27 kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>L-Trp -</td>
<td>L-Trp +</td>
</tr>
<tr>
<td>Corn</td>
<td>28.8</td>
<td>28.8</td>
</tr>
<tr>
<td>Corn gluten</td>
<td>5.7</td>
<td>5.7</td>
</tr>
<tr>
<td>Whey</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Soybean meal</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>Pea</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>Vegetal oil</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Calcium carbonate</td>
<td>1.47</td>
<td>1.47</td>
</tr>
<tr>
<td>Phosphate</td>
<td>1.79</td>
<td>1.79</td>
</tr>
<tr>
<td>Sel</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Vitamines/Minerals</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>L-Lysine HCI</td>
<td>0.34</td>
<td>0.34</td>
</tr>
<tr>
<td>DL-Methionine</td>
<td>0.20</td>
<td>0.20</td>
</tr>
<tr>
<td>L-Threonine</td>
<td>0.11</td>
<td>0.11</td>
</tr>
<tr>
<td>L-Tryptophan</td>
<td>–</td>
<td>0.06</td>
</tr>
<tr>
<td>MAT, %</td>
<td>20.6</td>
<td>21</td>
</tr>
<tr>
<td>Trp:Lys SID expected</td>
<td>0.15</td>
<td>0.19</td>
</tr>
<tr>
<td>Trp:Lys total analysed</td>
<td>0.19</td>
<td>0.22</td>
</tr>
</tbody>
</table>
Figure 18: Effect of dietary tryptophan and depressing sanitary status on weight gain and feed intake of pigs from 8 to 27 kg, AB means antibiotics in the diet (Le Floc’h et al, 2005)

There is no significant interactions between dietary tryptophan and sanitary conditions on growth performance and plasma tryptophan. Despite the rationing some feed refusal are noticed especially in pigs kept in the dirty environment and fed the low tryptophan diet (Figure 18). For the whole period, tryptophan supplementation increases significantly (P < 0.001) weight gain and feed intake and decreases feed conversion (Figure 18).

Figure 19: Effect of dietary tryptophan and depressing sanitary status on plasma tryptophan concentration measured at 12, 33 and 47 days postW (Weaning) (Le Floc’h et al, 2005)

Additionally, the variability of plasma tryptophan concentrations between the different time of the postweaning period is higher in the low sanitary status group of piglets compared with the high sanitary group (Figure 19).

In the dirty environment, the significant effect of tryptophan on growth suggests that growth depression caused by unsanitised conditions could be limited by increasing dietary tryptophan level.

**Tryptophan and health status**

**Conclusions:**
- When health status deteriorates, tryptophan utilisation is increased.
- The impact of inflammatory challenge is partly alleviated in pigs fed tryptophan adequate diet compared to tryptophan deficient diet.

**Implications:**
Importance of maintaining adequate tryptophan supply Trp:Lys 22% SID in order to optimise growth especially in conditions where health status is depressed.
General Conclusions

- Feed intake, growth, and feed conversion are optimised when the dietary tryptophan to lysine ratio is set at 22% SID in piglets (7 to 30 kg).

- Tryptophan is a key nutrient to optimise feed intake and part of the effect on growth is obtained through enhancement of ingestion.

- Tryptophan utilisation is increased when health status deteriorates, even moderately, which emphases the importance of maintaining an adequate dietary tryptophan level (Trp:Lys 22% SID) in piglet diets.
### Table 1: Summary of experimental design. M (Male), F (Female).

<table>
<thead>
<tr>
<th>Genotype*</th>
<th>Sex</th>
<th>Number of pigs per treatment</th>
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* LW: Large White, DL: Dutch Landrace, LD: Landrace, GY: Great Yorkshire, C: Camborough, GL: German Landrace

### Table 2: Composition and main nutritional values of the basal experimental diets. Pst means prestarter and st starter

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</table>

* For diet containing blood meal or meat and bone meal, trials have been done before prohibition of these products in the European Union.


Pampuch, F.G.; Paulicks, B.R.; Roth-Maier, D.A., 2004. Influence of the dietary trypt-


