Arguments supporting the use of standardised ileal amino acid digestibility in broilers

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Broilers feed formulations based on digestible amino acids are more accurate and more cost effective than those based on total amino acids. The aim of this paper is to screen the differences between digestible amino acid measurements carried out either at the ileal level or at the faecal level. These differences include the surgical procedure, the age of the animal, the type of diet/substances tested, the actual gut stimulation, the microbial fermentation contamination and the urine contamination. All these parameters may influence the final result. Finally, the comparison of amino acid digestibility coefficients in different raw materials expressed as true faecal or standardised ileal digestibility clearly shows the lack of systematic correlation between the two systems. This demonstrates that the ranking of the nutritional value of the raw materials is affected by the digestibility system considered. Taken into account the differences between the two systems, it is concluded that the standardised ileal digestible system should be preferred compared to the true faecal digestible system for the operational broiler feed formulation.

Keywords: amino acids, broiler, digestibility

Introduction

It is known that a proportion of dietary amino acids is excreted undigested and that individual raw materials differ widely in this respect. Thus, the higher the inclusion levels of raw materials with low amino acid digestibility in diets formulated on the basis of total amino acids, the less reliable will be the prediction of performance (Esteve-Garcia et al., 1993; Fernandez et al., 1995; Pertillà et al., 2001a). This matter in fact leads to the implementation of safety margins and reduction of the number of raw materials utilised in order to avoid any potential reductions in live performance.

Nowadays, poultry production is a highly integrated sector. Even the yield definition varies regionally or from enterprises to enterprises, the impact of feed cost is always one of the most important issues. In this context, knowledge of digestibility coefficients for individual amino acids in raw materials and also the requirement of digestible amino acids for a defined production target (such as maximising growth, breast meat yield and/or profitability, or minimising feed conversion ratio and/or feed costs per kg gain or breast meat) enables formulation of diets in a more flexible and cost effective way. Indeed, a better knowledge of digestible amino acids may enable a higher use of alternative protein sources, because such formulations will improve the precision of least cost diets from poultry operations. Finally, diet formulations on a digestible amino acid basis may also offer economic benefits (Rostagno et al., 1995).

A large volume of published data on the amino acid digestibility of raw materials for poultry is available. But there is still a considerable confusion in the terminology used due to differences in the methodology employed for determining digestibility coefficients (Ravindran and Bryden, 1999) including class of birds (broilers or roosters), site of measurement (excreta or ileal) and correction for basal endogenous losses (standardised or apparent). This paper is not focussed on the different methodological approaches of assessing amino acid digestibility since many reviews have been recently published. This paper emphasises the differences between faecal and ileal digestibilities and why the latter (as in swine nutrition) should be preferred. In contrast to swine where a large body of
Differences between True faecal digestible measurement and ileal digestible measurement

Today three different methods are used to measure the digestibility of amino acids in broilers. The faecal digestibility that is a direct measurement in intact birds. When using caecectomized birds also faeces are collected but caeca of the birds have been removed in order to decrease the influence of hindgut fermentation on amino acid digestibility. For ileal digestibility, digesta are obtained at the terminal ileum. Amino acid digestibility may considerably vary depending on the choice of one of the three methods.

Technical procedure: In contrast to the direct collection of faeces, caecctomization and ileal digestibility assays require invasive technical procedures. For the latter, two methods are available. On the one hand, digesta can be obtained from the ileum after slaughtering the bird. This is the more established approach. An alternative is to use an ileal cannula. There are three main advantages of faeces collection from both intact and caecectomised birds compared to the ileal digestibility assay: 1) faeces collection enables the use of the animal for a long period and therefore enables the comparison of different raw materials within the same animal. This allows for more powerful statistical comparisons taking into account the animal influence. However, it should also be added that the total variation is greater with faeces collection than with ileal digesta collection. (Ravindran et al 1999) 2) Because each animal can be used to test several ingredients, a smaller number of animals are needed to generate digestibility coefficients. 3) Faeces collection from intact birds, but to a certain extend also from caecectomised birds, might be more accepted from an ethical point of view than the slaughter method. These disadvantages of ileal digestibility measurements could be overcome by establishing cannulation techniques, which is practicable only in mature birds.

Age of the animal: In contrast with caecectomised roosters and with many faecal digestibility trials, growing broilers are used to determine ileal digestibility. It has been well described in the literature, that the digestibility performance of the chick develops rapidly over the first weeks of age leading to variations in amino acid digestibility both within a given raw material and among raw materials for a given amino acid (Huang et al 2005). It has, therefore, been concluded that there is no simple correction to derive the digestible coefficient determined at a given stage to an other stage. Digestibility values given in a table shall be used in practical broiler nutrition and, thus, digestible coefficients should be determined with animals with an age close to the regular production stage.

Feed versus test substance: In contrast to the ileal digestibility, common method for the excreta assay is to force feed the birds by application the test ingredient into the crop. This may exert a significant influence on the digestive processes simply because the nutrient supply is not balanced. Generally, feed is a complex blend of different components providing nutrients and energy in sufficient amounts. Providing either deficient (or suboptimum) or excessive quantities of a nutrient could lead to some physiological disturbances. On the contrary, feeding the test ingredient as the only amino acid source in a test diet fortified with key nutrients and energy as usually done in the ileal digestibility assay minimises the risk of such imbalances.

Gut stimulation: In the excreta assay, usually the adult cockerels are fasted for 24-48 hrs before force-feeding a defined amount of the test feedstuffs directly into the crop to ensure that no feed residues (i.e. contamination) remain in the digestive tract. The excreta are then collected for a sufficiently long period on the assumption that all undigested components have been excreted. However, stimulation or rather non-stimulation of the secretion of certain digestive enzymes and the general digestion processes induced by these fasting periods are relevant influence factors for amino acid digestion. The effect of feed restriction is well documented in layers as feed restriction is part of some management program to induce molt. One of the most critical points is that the overall metabolism has to adapt leading to a decrease of the nitrogen metabolism (Webster 2003). Moreover, it appears that the younger the animal the more pronounced the effect of fasting on metabolism.

Effect of hindgut fermentation: The excreta based measurements ignore the effects of microbial
hindgut fermentation on protein because of the contribution of microbial proteins to the amino acid concentrations in the faeces. This in turn can significantly affect the digestibility assessment (Kadim et al 2002) but this source of error can largely be overcome by caecectomizing the birds (Parsons, 1986). However, even in caecectomized broilers a microbial fermentation is taking place in the hindgut, which can influence the measurement.

**Effect of urinary amino acids:** By definition digestibility is a balance between intake and faecal excretion. However, excreta collected in the faecal digestibility assay contain not only amino acids from the faeces but also those excreted with the urine. It would therefore be more accurate to refer to this faecal measurement as ‘metabolizability’ rather than digestibility. Although some sources point out that renal AA excretion is negligible (Terpstra, 1978), there is some evidence suggesting that this is not always the case (McNab, 1995). Tossenberger et al (2005, unpublished data) showed the impact of the urine contamination on the digestible coefficient evaluation. The urine contamination would reduce the amino acid digestibility by about 2 points. Ileal measurement overcomes this problem since urine doesn't interfere at this level with digesta collection.

**Raw material ranking**

Many digestibility tables based on faecal amino acid digestibilities have been published recent decades. To our knowledge only one digestible table based on standardised ileal amino acid digestibilities of several important raw materials have been published (Lemme 2005). This database is mainly based on assays carried out by the University of Sidney, NSW, Australia and Degussa AG but also on some literature data. What is the impact of these theoretical considerations on the day to day formulation practice? The basis of least cost formulation is to rank raw material according to both their price and the nutritive value and then to find the cheapest compromise meeting all constraints. In this regard, the digestible amino acid system is more powerful compared to the total digestible amino acid system because the nutritive value of the raw materials is better evaluated. Table 1 presents the differences between the true faecal digestible system (Sauvent et al 2002) and the standardised ileal digestible system (Lemme 2005) for some selected raw materials and amino acids. Differences varied from between -14 to +10 points. Some raw materials show systematic discrepancies: barley and lupines and corn gluten meal. Accordingly, digestibility coefficients of barley are systematically lower in the true faecal digestible system whereas those of lupines and corn gluten meal are higher. For other raw materials the picture is not as consistent. Regarding corn, rapeseed meal and sunflower meal, lysine is lower but threonine and total sulphur amino acids are higher in the true faecal digestible system compared to the standardised ileal system. This overall lack of consistency between the two systems prevents the use of any systemic and easy correction factor. As a consequence the ranking of the nutritional value of the raw materials is affected as demonstrated earlier by Ravindran and Bryden (1999). Since many of the methodological sources of error related to the excreta digestibility assay can be avoided or minimised by the ileal digestibility assay, the latter is assumed to be more reliable and thus recommended to be used in practical feed formulation. However, it should be added that the body of data available is small compared to that of faecal digestibility. Therefore, more efforts are needed in order to supplement and to improve the current data on standardised ileal amino acid digestibility.

**Conclusion**

This paper discusses the methodological differences between amino acid digestibilities determined either by the faecal digestibility assay or by the ileal digestibility assay. These differences are factors like the surgical procedure, the age of the animal, the type of diet/substances tested, the feeding method, the gut stimulation, the microbial fermentation in the gut and the contribution of urinary amino acids. All these parameters exert a significant influence on the digestible coefficient evaluation. Moreover the comparison of single amino acid digestibility coefficients expressed as true faecal or standardised ileal in different raw materials demonstrated the lack of a systematic correlation between the two systems. Taken this into account it is concluded that the standardised ileal digestible system
should be used for operational broiler feed formulation.

Table 1: Differences between true faecal digestible coefficients (Faecal) and standardised ileal digestible coefficients (Ileal) for selected raw material and amino acids.

<table>
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<th>Grains</th>
<th>Lys</th>
<th>Faecal</th>
<th>Ileal</th>
<th>Diff.</th>
<th>Met</th>
<th>Faecal</th>
<th>Ileal</th>
<th>Diff.</th>
<th>M+C</th>
<th>Faecal</th>
<th>Ileal</th>
<th>Diff.</th>
<th>Thr</th>
<th>Faecal</th>
<th>Ileal</th>
<th>Diff.</th>
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<td>85</td>
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References


