# Effect of particle size on precaecal digestibility of amino acids from maize and soybean meal in broilers

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**Maize and solvent extracted soybean meal (SBM) were ground through a 2 or 3 mm screen, resulting in "fine" and "coarse" material. The mean particle sizes of fine and coarse feed were 0.62 *vs.* 0.96 mm (maize) and 0.63 *vs.* 1.01 mm (SBM). Maize or SBM of either particle size was included in experimental diets at two different levels at the expense of maize starch. Three week old broilers had free access to one of the 9 diets for a period of 7 days. Six pens of 10 broilers were allocated to each diet. Digesta was sampled from a standardised section of the terminal ileum immediately after slaughter. Precaecal digestibility of amino acids was calculated for maize and SBM by linear regression analysis, which considers the basal endogenous amino acid losses. All amino acids from coarse maize were higher digested than from fine maize, with a mean difference of 6.3%. In contrast, all amino acids from coarse SBM were less digested than from fine SBM, with a mean difference of 5.5%. It is concluded that particle size affects amino acid digestibility and that this effect is different between feed ingredients. Therefore, standardising particle size is important in routine studies on amino acid digestibility of feed ingredients.**

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**Keywords**: particle size; precaecal digestibility; amino acids; broilers

## Introduction

The digestibility of amino acids (AA) becomes increasingly relevant as a criterion of feed evaluation for optimising feed compounding in broilers. In order to minimise the effect of post-ileal fermentation, AA digestibility is best measured prior to the ileo-caeco-colonic junction (Ravindran et al., 1999). Precaecal (pc) digestibility measurements may be affected by AA of endogenous origin, commonly divided into basal and specific endogenous losses. While basal endogenous losses generally depend on the level of feed intake, only the specific losses are caused by the feed protein under study. Consequently, special attention is given to the consideration of basal endogenous losses in digestibility studies.

It is known that details of production, handling and processing of a feed ingredient can affect its feeding value. The effects of particle size on performance and nutrient digestibility were studied by several groups (Fastinger & Mahan, 2003; Parson et al., 2006; Wondra et al., 1995). Results were not consistent across different feeds and animal species.

The objective of the present study was to give special attention to the effect of particle size on pc AA digestibility. Maize and solvent extracted soybean meal from dehulled seed (SBM) were chosen as test ingredients because of their high relevance in poultry feeding. A regression approach with two levels of supplementation was used because it implies consideration of basal endogenous losses (Rodehutscord et al., 2004).

## Materials and methods

Maize and SBM were ground in a hammer mill using sieves with a pore size of either 2 or 3 mm. The ground material was characterised regarding the distribution of particle size by separating 100 g of feed for 1 min through 7 sieve layers with standardised pore sizes (3.15 to 0.25 mm). Six replicated measures were made with each feed.

A total of 9 experimental diets was used. The basal diet mainly contained maize starch, maize, soybean meal, wheat gluten and AA in free form in order to achieve recommended dietary AA levels. $TiO_2$ was included as indigestible marker. In the 8 other diets, one of the test feeds was included. Maize was included at levels of 250 and 500 g/kg, and SBM at levels of 150 and 300 kg. Inclusion was made at the expense of maize starch, so that the differences in AA content of the diets resulted from the test feeds only. Diets were pelleted through a 3-mm die without using steam.

Five hundred and forty Ross 308 broiler hatchlings were distributed to 54 floor pens that were 1.7 $m^2$ in size. A commercial starter feed was used until d 14. Then 6 pens were allocated by random to 1 of the 9 experimental treatments and diets were offered *ad libitum* for 7 d. On d 21 broilers were asphyxiated by $CO_2$ exposure and the intestines were quickly removed. The section between Meckel's diverticulum and the ileo-caeco-colonic junction was taken and digesta from the terminal two thirds of this section were collected on a pen basis (Kluth et al., 2005). The contents of crude protein, AA and $TiO_2$ were measured in diets and freeze-dried digesta samples according to established methods.

The pc digestibility of AA from maize and SBM was calculated by using linear regressions. These regressions use the quantitative data for the pc digested AA and AA intake. Basal endogenous AA losses are contained in the intercept of the regressions and are thus not relevant for the estimates of digestibility which are based on the slopes (Rodehutscord et al., 2004). Linear regressions and F-test for comparison of slopes were calculated using the GraphPad Prism software (version 4.2).

## Results and discussion

Particle size distribution of the two test feeds was distinctly different after grinding (*Figure 1*). When ground through the 3 or 2-mm sieve mean particle size of maize was 0.96 mm ("coarse") and 0.62 ("fine"). The corresponding values for SBM were 1.01 (coarse) and 0.63 mm (fine).

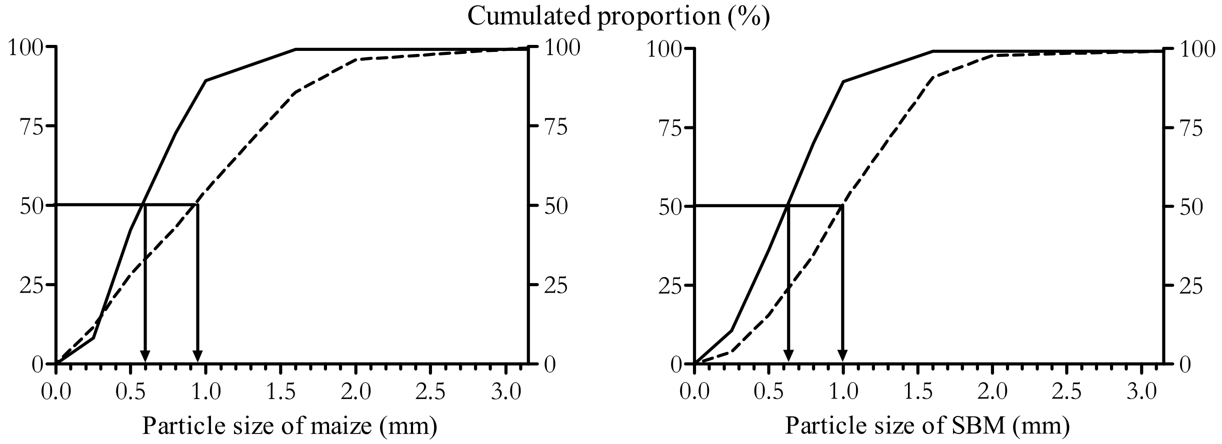

**Figure 1 Cumulative proportion of analysed particle sizes in maize and soybean meal (SBM) ground through sieves with 2 mm (closed line) or 3 mm (dotted line) pore size (arrows indicate the mean particle size)**

Precaecal digestibility of CP from coarse and fine maize was 80 and 74 %, respectively (*Table 1*). Digestibilities of AA ranged from 70 to 90 % in coarse maize and from 65 to 87 % in fine maize. All AA were higher digested in coarse than in fine maize (2 to 11 %), and these differences were statistically significant for most of the AA ($P<0.05$).

These findings are in line with studies that reported positive effects on performance when coarse maize particles were fed. Nitrogen retention increased linearly with increasing particle size of the maize fed (Parson et al., 2006). This study also indicated that passage rate decreased with increased particle size, which led to the conclusion that reduced passage rate caused higher digestibility and retention (Parson et al., 2006). This hypothesis is supported by the present data. Similarly, positive effects on the efficiency of utilisation of P and Ca when coarse maize was fed were reported in broilers (Kasim & Edwards, 2000) and young turkeys (Charbeneau & Roberson, 2004). In pigs, however, a linear increase in faecal digestibility of dry matter, N and gross energy was measured when finer maize particles were used. This was discussed as a consequence of increased particle surface and improved exposure of feed to proteolytic enzymes (Wondran et al., 1995).

In contrast to the differences found in maize, the pc digestibility of CP from SBM was higher in the fine material (78 %) than in the coarse (73 %) (*Table 1*). Digestibilities of AA from fine SBM ranged from 56 to 86 % and were higher for all AA than in the coarse SBM (49 to 82 %). Differences for individual AA between fine and coarse ranged from 4 to 9 % and were statistically significant for 5 of the AA studied.

Particle size effects were hardly studied with oilseed meals in poultry. Kilburn & Edwards (2004) could not find a clear effect of particle size on the retention of Ca, total P and phytate P from SBM in broilers. Similar results were described for 2-wk old turkeys, but in 4-wk old turkeys a linear increase in utilisation of phytate P was measured (Charbeneau & Roberson, 2004). In contrast to the present results it was measured with pigs that pc digestibilities of essential AA increased with increasing particle size (Fastinger & Mahan, 2003).

The effects of particle size on digestibility are often discussed in relation to passage rate and particle surface in conjunction with digestive enzyme activity. In the present study maize and SBM may have had different passage rates due to their differences in CP, crude fibre and starch contents. Along this hypothesis further studies are needed that look into the interactions of particle size and passage rate for different feed ingredients. In theory, digestibility may be influenced by dietary factors that modify the basal endogenous losses. Such effects were not relevant for explaining the present results because the approach implied that endogenous losses are not contained in the measure of digestibility. The effects of particle size on AA digestibility in different feedstuffs from the present study may help to explain the contradicting results from other studies that looked into bird's performance.

It can be concluded that particle size affects pc AA digestibility differently for different feed ingredients. In routine feed evaluation this effect has to be considered when data are to be brought together in a feed table. Differences in digestibilities found between studies for the same ingredient may be caused by the way samples were ground. A definition of "optimal" particle size is, however, difficult, because it depends on ingredient and batch specific characteristics. With respect to the application in practise it may be reasonable to adjust the methodological standards for grinding to the practise applied in feed mills.

**Table 1 Precaecal digestibility of crude protein and amino acids, determined by linear regression analysis (%, SE)**

| | Maize | | | Soybean meal | | |
|---|---|---|---|---|---|---|
| Ground through … | 2 mm | 3 mm | *P* | 2 mm | 3 mm | *P* |
| Crude protein | 74 (1.9) | 80 (2.2) | 0.066 | 78 (2.1) | 73 (1.4) | 0.063 |
| Alanine | 74 (2.1) | 80 (2.0) | 0.045 | 74 (2.7) | 69 (1.8) | 0.189 |
| Arginine | 84 (1.6) | 89 (1.4) | 0.037 | 86 (0.9) | 82 (1.1) | 0.011 |
| Aspartic acid | 65 (3.1) | 74 (3.1) | 0.023 | 75 (1.9) | 71 (1.5) | 0.112 |
| Cystine | 67 (2.2) | 70 (2.3) | 0.303 | 56 (3.2) | 49 (3.5) | 0.121 |
| Glutamic acid | 81 (1.4) | 86 (1.5) | 0.024 | 83 (1.7) | 79 (1.4) | 0.090 |
| Glycine | 66 (2.3) | 73 (2.6) | 0.067 | 73 (2.1) | 67 (2.0) | 0.035 |
| Isoleucine | 76 (2.2) | 83 (2.4) | 0.033 | 79 (2.1) | 74 (1.5) | 0.073 |
| Leucine | 77 (1.8) | 83 (1.7) | 0.020 | 77 (2.3) | 72 (1.7) | 0.102 |
| Lysine | 79 (2.1) | 86 (2.3) | 0.058 | 83 (1.4) | 79 (1.4) | 0.019 |
| Methionine | 87 (1.4) | 90 (1.9) | 0.214 | 83 (3.1) | 77 (1.9) | 0.092 |
| Phenylalanine | 77 (2.2) | 83 (2.0) | 0.045 | 79 (2.1) | 75 (1.7) | 0.125 |
| Proline | 79 (1.8) | 81 (1.7) | 0.297 | 80 (3.5) | 71 (3.5) | 0.066 |
| Serine | 70 (2.9) | 81 (2.2) | 0.003 | 77 (2.3) | 72 (1.8) | 0.116 |
| Threonine | 71 (2.8) | 81 (2.4) | 0.009 | 76 (2.8) | 68 (2.1) | 0.048 |
| Valine | 77 (1.9) | 83 (2.2) | 0.041 | 78 (2.3) | 71 (1.8) | 0.030 |

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