INFLUENCE OF PARTICLE SIZE ON THE PERFORMANCE, DIGESTA
CHARACTERISTICS AND ENERGY UTILISATION OF BROILERS FED MAIZE AND
WHEAT BASED DIETS

A.M. AMERAH¹, V. RAVINDRAN¹, R.G. LENTLE¹ and D.G. THOMAS¹

Summary

The effects of grain type (wheat and maize) and particle size (fine and coarse) on the
performance, digesta characteristics and nutrient utilisation of broilers during 1-21 days post-
hatching were investigated. Coarse grinding improved (P<0.05) bird performance and
increased (P<0.05) relative gizzard weights compared to those fed diets based on fine
particles. Differences in particle size distribution still existed between diets after pelleting
especially in the proportion of coarse particles (1 mm and over). However, grinding in the
gizzard evened out differences in particle size between the diets, which resulted in no
difference (P>0.05) in particle size distribution in the duodenal digesta of the birds fed diets
based on fine and coarse particles. Grain particle size had no effect (P>0.05) on apparent
metabolisable energy. The results of the present study suggest that coarse grinding is
advantageous to broiler performance.

I. INTRODUCTION

Available evidence suggests that grain particle size is more critical in mash feeds, but
less so in pelleted feeds (Nir et al., 1995; Svihus et al., 2004). However, pellets dissolve in
the crop after consumption (Nir and Ptichi 2001) and the effects of particle size on broiler
performance may be maintained even after pelleting.

Grain type is known to influence the particle size when milled under the same
conditions, with grinding through the same screen size in a hammer mill yielding different
particle size distributions. This suggests that during grinding using a hammer mill, different
screen sizes may have to be used according to the grain type to obtain the desired particle size
distribution. Nir et al. (1995) reported that grinding wheat with the same hammer or roller
mill under the same conditions gave higher geometric mean diameter (GMD) compared to
sorghum. In the study reported herein, the effects of grain type (wheat and maize) and
particle size (fine and coarse) on broiler performance, digesta characteristics and energy
utilisation were investigated.

II. MATERIALS AND METHODS

The experimental design was a 2 x 2 factorial testing two grains (wheat vs. maize) and
two particle sizes (fine vs. coarse); all diets were fed in pelleted form. The two particle sizes
were achieved by grinding the whole wheat and maize in the hammer mill to pass through 1
and 7 mm sieves. Broiler starter diets, based on wheat and soybean meal or maize and
soybean meal, were formulated. Each diet was fed to six pens of eight male broilers (Ross)
each from day 1 to 21 post-hatching. The diets were offered ad libitum and water was freely
available at all times.

Body weights and feed intake were recorded at weekly intervals, and FCR, corrected
for mortality, was calculated. From day 17 to 20 post-hatching, feed intake and total excreta

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output were measured quantitatively per pen for the determination of nitrogen-corrected apparent metabolisable energy (AME\textsubscript{n}). On day 21, two birds per replicate, closest to the average pen weight, were selected. The birds were euthanised and digesta samples from the duodenum were obtained. Particle size spectra in the diet and duodenal digesta samples were determined using the wet sieving method as described by Lentle et al. (2006). Briefly, the diet and digesta samples were suspended in 50 ml of water and left to stand for 30 min prior to sieving to ensure adequate hydration. The samples were then wet sieved in a set of Endecott (London, U.K.) sieves of size 2, 1, 0.5, 0.25, 0.106 and 0.075 mm. The masses of particles from each sieve were expressed as percent of total dry matter recovered including fines. The data were statistically analysed using the General Linear Models procedure of SAS (1997). Particle size distributions were compared by discriminate analysis in SYSTAT (Wilkinson, 1990).

III. RESULTS AND DISCUSSION

Wet sieving of pelleted diets indicate that the differences in particle size distribution still existed between diets after pelleting especially in the proportion of coarse particles over 1mm (Figure 1).

![Particle size distribution of pelleted diets](image)

Figure 1. Particle size distribution of pelleted diets

The influence of dietary treatments on the performance of broilers is summarised in Table 1. Grain type tended (P=0.06) to influence weight gains, with birds on wheat-based diets having a greater gain than those on maize-based diets. There was, however, a tendency (P=0.07) for treatment interactions, with a particle size effect being evident only in maize-based diets. Feed intake was influenced (P<0.001) by grain type, with the intake of wheat-based diets being greater than those of maize-based diets. Particle size affected feed intake in wheat-based diets and not in maize-based diets, as indicated by a tendency (P=0.10) for treatment interaction. Birds fed maize-based diets had a better (P<0.001) feed efficiency than those fed wheat-based diets. FCR was lower on coarse than finely-ground grain diets (P<0.001). No interactions (P > 0.05) were observed for FCR.
Table 1. Weight gain (g/bird), feed intake (g/bird), FCR (g/g), AME\textsubscript{a} (MJ/kg DM) and relative gizzard weight (g/kg BW) of broilers as influenced by grain type (G) and particle size (PS)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Wheat</th>
<th>Maize</th>
<th>SEM</th>
<th>Significance (P&lt;0.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>Weight gain</td>
<td>888.0</td>
<td>872.0</td>
<td>823.0</td>
<td>870.0</td>
</tr>
<tr>
<td>Feed intake</td>
<td>1357.0</td>
<td>1262.0</td>
<td>1191.0</td>
<td>1173.0</td>
</tr>
<tr>
<td>FCR</td>
<td>1.528</td>
<td>1.467</td>
<td>1.448</td>
<td>1.360</td>
</tr>
<tr>
<td>AME\textsubscript{a}</td>
<td>12.07</td>
<td>12.41</td>
<td>13.25</td>
<td>13.04</td>
</tr>
<tr>
<td>Gizzard wt.</td>
<td>9.03\textsuperscript{a}</td>
<td>10.08\textsuperscript{a}</td>
<td>9.40\textsuperscript{b}</td>
<td>12.63\textsuperscript{b}</td>
</tr>
</tbody>
</table>

\textsuperscript{a,b} Means in a row not sharing a common superscript differ (P < 0.05).

For maize diets, previous research has shown that birds fed fine maize in pelleted form had better feed efficiency than those fed coarse particles (Lott et al., 1992; Kilburn and Edwards, 2001). Lott et al. (1992) reported that fine maize (GMD, 716 microns) improved broiler performance compared to those fed coarse particles in (GMD, 1196 microns) in crumbled form. In contrast, coarsely ground maize resulted in better feed efficiency in the present study.

Published data on the effects of wheat particle size in pelleted diets on broiler performance have been contradictory. Peron et al. (2005) reported a tendency for better feed efficiency in birds given coarse wheat (GMD, 955 microns) compared to those fed fine ground wheat (GMD, 388 microns) and this enhancement was associated with a greater relative gizzard weight. Lentle et al. (2006), using three different wheat cultivars, also found that the diet with the higher relative proportion of coarser particles resulted in the best feed/gain in broiler chickens. These findings are similar to those observed in the present study. On the other hand, Svilhus et al. (2004) reported that pelleting evened out differences in particle size distribution in the pelleted diets and no effect of wheat particle size on broiler performance was observed in their study. It would, therefore, appear that the effect of particle size in pelleted diet may depend on particle size distribution after pelleting, which in turn may depend on the hardness of the grain used.

In this study, grain particle size had no effect (P>0.05) on the AME values (Table 1). However, there was a tendency for treatment interaction (P=0.06) with coarse grinding improving the AME in wheat-based diets and not in maize-based diets. This finding is in disagreement with those of Svilhus et al. (2004) who reported no effect of wheat particle size and of Kilburn and Edwards (2001) who found that fine grinding of maize improved true metabolisable energy values.

Relative gizzard weights were increased (P<0.05) by coarse particles (Table 1). However, the increases were greater in the maize-based diets than in the wheat-based diets as indicated by a significant (P<0.01) grain type x particle size interaction.

The discriminant analysis failed to show distinction (P>0.05) between particle size distributions of the duodenal digesta from birds fed fine and coarse particle sizes of wheat-based diet (Table 2). Similarly, the discriminate analysis failed to show significant difference (P>0.05) between particle size distributions of duodenal digesta from birds fed fine and coarse particle sizes of maize. These results suggest that the gizzard evened out the differences in particle size of the diet.
Table 2. Proportion of particle size classes (mean ± SE) in the duodenal digesta (on a dry weight basis) of broilers as influenced by grain type and particle size

<table>
<thead>
<tr>
<th></th>
<th>Wheat</th>
<th>Maize</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fine</td>
<td>Coarse</td>
</tr>
<tr>
<td>&lt;0.075mm</td>
<td>0.535±0.058</td>
<td>0.463±0.040</td>
</tr>
<tr>
<td>0.075-0.106mm</td>
<td>0.056±0.010</td>
<td>0.077±0.013</td>
</tr>
<tr>
<td>0.106-0.25mm</td>
<td>0.167±0.021</td>
<td>0.184±0.031</td>
</tr>
<tr>
<td>0.250-0.500mm</td>
<td>0.134±0.025</td>
<td>0.151±0.026</td>
</tr>
<tr>
<td>0.500-1.000mm</td>
<td>0.094±0.048</td>
<td>0.067±0.014</td>
</tr>
<tr>
<td>1.000-2.000mm</td>
<td>0.013±0.002</td>
<td>0.046±0.010</td>
</tr>
</tbody>
</table>

Under the conditions of the present study, grain particle size maintained its effect after pelleting; birds fed coarse particle size diets showed better feed efficiency than those given finely ground grain diets. The former group had larger gizzards, which is thought to be beneficial in terms of the motility, function and gut health (Ferket, 2000; Gabriel et al., 2003).

REFERENCES