Pig preference for cereal based diets, relationship with their digestibility and physical properties

D. Solà-Oriol, E. Roura, D. Torrallardona

Abstract

One of the most important challenges in pig farming is to overcome the initial anorexia of the pig at weaning. Since the use of palatable ingredients should facilitate the initiation of feeding at weaning, we have previously conducted a series of trials to measure the preference of pigs for different cereals. Preference is driven by odour and taste, but the physical and post-ingestive properties of the cereals could also have an effect. The present trial aims to study the relationship between the preferences for diets with 60% of rice, barley, sorghum or oats and their digestibility and physical properties. We measured the ileal and faecal digestibilities of dry matter, organic matter, and crude protein, and the proximal GIT emptying (from the flow of digesta through the ileal cannula) for 12 h after feeding. Particle size profile, viscosity, swelling and water retention capacity and texture (hardness, fragility, chewing effort and stickiness) of the four diets, were also measured. Pearson’s correlation coefficients with feed preference were statistically significant ($P < 0.05$) for particle size profile and texture of the feeds. They tended to be significant ($P < 0.1$) for ileal digesta viscosity, faecal dry matter digestibility and proximal GIT emptying rate. Additional studies of palatability for cereals should consider these parameters in order to confirm this.

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Keywords: Cereal; Palatability; Texture; Digestibility; Pigs

1. Introduction

Piglets at weaning undergo a severe reduction in dry matter intake due to low voluntary feed intake (Pluske et al., 1997). The use of palatable diets during this phase should diminish this negative effect and overcome the initial anorexia of the pig at weaning. A series of double-choice trials were performed previously to measure the preference of piglets for different cereal based diets against a reference basal diet; expressing the preference for each cereal based diet as the percentage contribution of that diet to total feed intake (Solà-Oriol et al., 2005). It was hypothesised that diets with a higher preference would facilitate the initiation of feeding after weaning. Although preference for the different cereals is driven by their flavour (odour and taste) (Goff and Klee, 2006), the possible effect of their physical and post-ingestive characteristics is not known. The present trial was conducted to study the relationship between the preference for diets with 60% of rice, barley, sorghum...
or oats (which were representative of the rank of preferences observed previously: 47.1, 22.8, 11.2, 3.0% of preference, respectively) and their digestibility and physical properties.

2. Materials and methods

The experimental procedures with animals described in this study were approved by IRTA’s Ethical Committee on Animal Experimentation (CEEA).

2.1. Experimental design

Twelve 30-kg pigs (Pietrain x Landrace) fitted with a T-cannula at the terminal ileum were offered four experimental diets (based on Rice, Barley, Oat or Sorghum) in four experimental periods according to a triple latin-square design. Each period consisted of seven days: four days of adaptation followed by 1 day of faecal collection and 2 days of ileal collection. Additionally, a fifth period of 6 days (5 days of adaptation and 1 day of collection) was performed in order to study the proximal GIT emptying.

2.2. Diets and feeding

The diets were formulated to contain 60% of the cereal being studied (either broken rice, barley, oats or sorghum), 20% of soybean meal (56% CP), 13% wheat bran, 3% sunflower oil and amino acids, vitamins and minerals to meet or exceed the animals’ requirements (NRC, 1998). The basal rice diet was formulated to contain 12.5 g total lysine and 13.9 MJ ME per kg and the nutrient composition was not corrected for the different cereals.

Feed was offered as two identical meals twice a day at 08.00 and 16.00 h at 2.4 times energy maintenance requirements. In the last period, the evening meal of day 5 was omitted to ensure an empty stomach and small intestine on the morning of day 6. All the diets were presented in mash form and included 0.5% TiO2 as indigestible marker.

2.3. Analysis

Feed, faeces and ileal digesta were analysed for dry matter, ash, crude protein and titanium dioxide in order to calculate digestibility. Viscosity (cPs), water retention (wt/wt) and swelling capacity (vol/wt) and particle size profile were also measured by sieving according to the methods described by McConnel et al. (1974) and Canibe and Knudsen (2002). The texture characteristics of feed were also analysed with a TA-XT2 Texture Analyser (Stable MicroSystems, Surrey, UK), performing 5 simple compressions with a 30 mm diameter cylinder in a 60 mm diameter cylindrical container (15 mm of maximum penetration at a speed of 1 mm/s). Hardness, fragility, chewing effort and stickiness were calculated from the measured maximum force (kg), slope, work (kg m/s²) and adhesion (kg), respectively.

2.4. Calculations and statistical analysis

The particle size profile of the diets, digesta and faeces was calculated as the % of particles retained by sieves of different diameter on a dry weight basis. The ileal and faecal dry matter digestibility was calculated as 

Table 1

<table>
<thead>
<tr>
<th>Particle size</th>
<th>Feed</th>
<th>Ileal digestibility</th>
<th>Faecal digestibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;1 mm</td>
<td>−0.035</td>
<td>0.539</td>
<td>0.991**</td>
</tr>
<tr>
<td>&gt;0.75 mm</td>
<td>−0.911†</td>
<td>0.467</td>
<td>0.943*</td>
</tr>
<tr>
<td>&gt;0.5 mm</td>
<td>0.889</td>
<td>0.938†</td>
<td>0.898</td>
</tr>
<tr>
<td>&gt;0.25 mm</td>
<td>0.936†</td>
<td>0.892</td>
<td>0.901†</td>
</tr>
<tr>
<td>&gt;0.18 mm</td>
<td>0.983*</td>
<td>0.886</td>
<td>0.911†</td>
</tr>
<tr>
<td>&gt;0.16 mm</td>
<td>0.479</td>
<td>0.883</td>
<td>0.907†</td>
</tr>
<tr>
<td>&lt;0.16 mm</td>
<td>−0.147</td>
<td>0.715</td>
<td>0.887</td>
</tr>
</tbody>
</table>

†: \( P<0.1 \); *: \( P<0.05 \); **: \( P<0.01 \).

Table 2

<table>
<thead>
<tr>
<th>Viscosity</th>
<th>Water retention capacity</th>
<th>Swelling capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed</td>
<td>−0.581</td>
<td>−0.827</td>
</tr>
<tr>
<td>Ileal contents</td>
<td>0.936†</td>
<td>−0.101</td>
</tr>
<tr>
<td>Faeces</td>
<td>0.832</td>
<td>−0.579</td>
</tr>
</tbody>
</table>

ND: not determined †: \( P<0.1 \).

Table 3

<table>
<thead>
<tr>
<th>Dry matter</th>
<th>Organic matter</th>
<th>Crude protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ileal digestibility</td>
<td>0.618</td>
<td>0.618</td>
</tr>
<tr>
<td>Faecal digestibility</td>
<td>0.910†</td>
<td>0.899</td>
</tr>
</tbody>
</table>

†: \( P<0.1 \).
faecal DM digestibility according to particle size were calculated from the particle size profiles of feed, ileal digesta and faeces, using TiO₂ as indigestible marker. For each particle size category it was considered that particles in digesta or faeces not retained by the corresponding sieve (or a sieve of higher diameter) had been digested.

In the last period, fractional meal retention in the proximal GIT (estimated from ileal digesta flow) as a function of time (for each pig) was fitted with a modified power exponential function according to Siegel et al. (1988). The NLIN procedure of the statistical package SAS was used and the emptying rate \( k, \% / \text{min} \) and the extrapolated \( y \)-intercept \( (b) \) from the terminal portion of the curve were calculated. \( T_{1/2} \) (time to empty half of the contents; min) was calculated using the values of \( k \) and \( b \) and the lag time \( (T_{\text{lag}}; \text{min}) \) was calculated by setting the second derivative \( [y'(t)] \) equal to zero and solving for \( t \). When \( y'(t)=0 \), the rate of emptying has become constant and this corresponds with the time at which the first phase (the shoulder portion) of the curve ends and the terminal phase begins.

Pearson’s correlation coefficients between the average feed preference of each of the four cereal based diets and the corresponding averages for each of the parameters measured were obtained using the CORR procedure (SAS® Institute Inc, 1999).

### 3. Results

Significant correlations between feed preference and feed particle size were observed (Table 1). Particularly the \% of particles with a diameter between 0.25 and 0.18 mm showed a statistically significant \( (P<0.05) \) positive correlation. Dry matter digestibility according to particle size was not well correlated at the ileal level but there was a good correlation at faecal level. Rheological properties of feed and their corresponding digestive contents were in general not well correlated with feed preference (Table 2). As described above for particle size, only faecal dry matter digestibility tended \( (P<0.1) \) to correlate with feed preference (Table 3). On the other hand a clear significant negative correlation was found between feed preference and the texture parameters hardness and fragility (Table 4). Finally, feed preference also tended \( (P<0.1) \) to be correlated with proximal GIT emptying rate (Table 5).

### 4. Discussion

Marked differences in piglet preference for different cereal based diets have been reported (Solà-Oriol et al., 2005). It is well recognised that the flavour (odour and taste) of these cereals plays an important role in attracting the newly weaned pig to the new diet (Goff and Klee, 2006), but other parameters that may affect mouth and gastrointestinal tract sensation may also play an important role. Although we only studied a limited number of cereals, our results appear to confirm that the particle size profile and the texture of the feed may have a stronger effect on palatability than its rheological parameters. Effects of faecal dry matter digestibility, ileal digesta viscosity and rate of digesta passage in the small intestine are also suggested, and this is probably related to feedback from the gastrointestinal tract that regulates feed intake. All these parameters should be considered in addition to flavour in order to understand palatability of diets for pigs as a tool to overcome post-weaning anorexia.

### 5. Conclusions

Feed preference of the cereals considered is correlated with particle size profile and feed texture. Ileal digesta viscosity, faecal dry matter digestibility and proximal GIT emptying rate may also be related although no statistical significance was observed. Additional studies of cereal palatability should consider these parameters in order to confirm their association with feed preference.

### Acknowledgements

The authors wish to thank the technical support received from A. Romero and L. Guerrero. The assistance
of IRTA’s support, laboratory and farm staff in looking after the trials is also acknowledged. This study was supported by CICYT (project AGL2005–07438-C02–02)

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