

# Ileal and faecal digestibility of five different wheat samples in broilers

A. GUTIÉRREZ-ALAMO<sup>1\*</sup> P. PÉREZ DE AYALA<sup>1</sup> L. A. DEN HARTOG<sup>1,2</sup> M. A. W. VERSTEGEN<sup>2</sup> and M. J. VILLAMIDE<sup>3</sup>

<sup>1</sup> NUTRECO Poultry and Rabbit Research Centre, Casarrubios del Monte, 45950 Toledo, Spain, <sup>2</sup> Wageningen UR/ Animal Nutrition Group, 6709 PG Wageningen, The Netherlands, <sup>3</sup> E.T.S.I. Agrónomos/ Departamento de Producción Animal, UPM, 28040 Madrid, Spain.

\* Corresponding author: [a.gutierrez@nutreco.com](mailto:a.gutierrez@nutreco.com)

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Five samples from different wheats with observed low quality parameters either in the field or in the laboratory were collected and ileal and faecal digestibility determined in broilers. These samples ranged in starch content from 62 to 67% DM and in crude protein from 10 to 18% DM. Each wheat was added at 70% inclusion level in five balanced diets. Chromic oxide (Cr<sub>2</sub>O<sub>3</sub>) at 0.5% was used as a marker to determine the apparent metabolizable energy content (AMEn corrected for protein) and ileal and faecal dry matter (DM), starch and protein digestibilities of wheat based diets. The trial involved a 10 d feeding period to growing broilers (21 to 30 d of age). Excreta was daily collected for the last 3 days. After that, the chickens were slaughtered to collect ileal chyme. Results obtained for ileal DM, starch and protein digestibilities were 64%, 94% and 75% as average, respectively. Moreover, DM and starch digestibilities were almost the same at ileal and at faecal level (63 and 93%, respectively), indicating no caecal fermentation of starch. The type of wheat had a significant effect ( $P < 0.05$ ) on faecal DM digestibility (ranging from 60 to 66%) and on crude protein retention ( $P = 0.06$ ) (ranging from 46 to 52%). However, no significant ( $P = 0.23$ ) effect of wheat sample was found neither in ileal or faecal starch digestibilities. As a consequence, differences in dietary AMEn did not reach significance ( $P = 0.06$ ), being 2854 kcal/kg DM its mean value. When the AMEn of the wheats was calculated by difference of a basal diet it ranged from 2968 to 3197 kcal/kg DM, being this difference mainly explained (60%) by the variation in digestible starch content. The AMEn of the wheat samples were positively related with their faecal digestibility of starch ( $r = 0.96$ ,  $P < 0.05$ ) and negatively related with protein content ( $r = -0.70$ ,  $P < 0.05$ ).

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## Introduction

Wheat is one of the main energy sources for poultry and other non-ruminants. It can provide up to 70% of the energy requirements and 30-40% of the amino acids requirements of broilers (McNab, 1996). Therefore any change in their quality has a direct impact in broiler performances and litter quality. Although wheat is generally considered as rather constant ingredient, some important differences in its energy value have been found (Mollah *et al.*, 1983; Wiseman, 2000). Starch is the largest energy yielding component of wheat, therefore a lot of research has been done on it. Some studies have found a positive correlation between starch content and AME (Svihus and Gullord, 2002) while others have not (Mollah *et al.*, 1983). Differences in AME can also be related to differences in starch digestibility, thus Mollah *et al.* (1983) and Rogel *et al.* (1987) have attributed the low metabolizable energy of some Australian wheats to a reduced starch digestibility (lower than 90%), and Svihus (2001) related the low AME of wheats non-supplemented with enzymes to their low starch

digestibility (79% as average). However, later studies in the same country (Annison, 1990) using 20 wheats did not find relationship between AME and starch digestibility. It seems that there is no problem of low energy wheats when they are given to adult animals. Svihus and Gullord (2002) observed an increase of 16% in the energy value of wheats obtained with cockerels compared to broilers. In the same way, Longstaff and McNab, (1986) found that the wheat starch digestion is almost complete when given to adult cockerels.

The aim of this work was to determine the ileal and faecal digestibility of nutrients and the energy value of some wheats that had shown low quality in field or in the laboratory.

## Material and methods

Five wheats with observed low quality parameters either in the field or in the laboratory were obtained from five different regions of Spain (Casarrubios del Monte, Griñón, Murcia, Reus, and Sevilla). Their chemical composition is shown in *Table 1*. All wheat samples were milled to pass through a 2.5 mm screen in a hammer mill and mixed at 700 g/kg with soyabean (254.5 g/kg), soya oil (16.2 g/kg), minerals (23.4 g/kg), amino acids (2.6 g/kg), premix with coccidiostats (3 g/kg) and chromic oxide (Cr<sub>2</sub>O<sub>3</sub>, 5 g/kg) as a marker. All experimental diets met or exceeded the recommended requirements (NRC, 1994). The experimental diets did not contain exogenous enzymes and were fed in mash form.

**Table 1** Chemical analysis (g/kg DM) of wheat samples

Wheat sample	Crude protein	Starch	Ether extract	Ash	NDF <sup>1</sup>
Casarrubios	108.1	673.7	16.6	16.7	149.1
Griñón	116.0	649.7	17.5	17.3	186.1
Murcia	187.9	622.8	15.9	18.3	162.3
Reus	167.2	648.0	16.3	18.2	132.3
Sevilla	137.0	658.0	13.5	17.5	165.2

<sup>1</sup> Neutral detergent fibre

A total of 200 one-day old male broiler chickens (Ross 308) obtained from a commercial hatchery (Cazalegas, Toledo, Spain) were allocated in 2 pens with wooden shavings, each containing 100 birds. Animals were fed a pre-experimental wheat-soya based starter feed (mash) for the first 3 weeks. At 21 days, all birds were weighed and 65 were selected for the experiment (light and heavy birds discarded) and randomised assigned to the five dietary treatments (13 replicates/treatment). The birds were individually allocated in metabolic cages that allowed individual excreta collection. They were fed the experimental feed *ad libitum* with an adaptation period of 7 days. Samples of excreta were collected for three consecutive days (from 27 to 30 days of age) and dried at low temperature (70 °C). Dry excreta for the 3 days of each cage was mixed and stored in airtight plastic tins until chemical analysis. On day 30, all birds were humanely killed. Immediately after, the small intestine was removed, the ileum was isolated as the intestine between the Meckel diverticulum and the ileo-cecal junction. Ileal content was collected by gently finger-stripping the ileal segment and stored at -80°C. After freeze-drying the samples, ileal content of each 2 animals per treatment was pooled in order to have enough quantity of sample for chemical analysis. All analysis, except Cr<sub>2</sub>O<sub>3</sub> in the feed (12 replicates), were carried out on duplicate and results reported on dry matter (DM) basis. Chemical analysis of the diets and excreta were conducted according to the methods of AOAC (1995) for DM (930.15), nitrogen (954.01), crude fibre (962.09), ether extract (960.39) and ash (942.05). Starch content was analysed following the alpha-amylglucosidase method (996.11, AOAC 1995). Neutral-detergent fibre was determined according to Van Soest *et al.* (1991). Chromium oxide content in feed and excreta was determined according to Fenton and Fenton (1979). Gross energy values were determined by bomb calorimeter using Parr 6100 adiabatic calorimeter (Parr Instrument Company, Moline, IL, USA).

The apparent metabolisable energy (AME) values corrected by zero nitrogen retention (AMEn) were determined in all experimental diets. The AMEn value of the different wheats was calculated by difference, as indicated by Villamide (1996). Dry matter and starch digestibilities of wheat based diets

were determined at both ileal and faecal level. Likewise, ileal protein digestibility and faecal protein retention were determined.

An analysis of variance using General Linear Model of the SAS software (SAS Institute, 1985) was used to determine the effect of the wheat sample on the nutritional value of wheat based diets. When the overall effect was significant ( $P < 0.05$ ), means were compared pairwise (pdiff). Results are given as least square means with a pooled standard error of the mean (SEM). Also a correlation analysis (proc corr) was carried out between the chemical composition and nutritional value of the experimental diets and wheats.

## Results and discussion

The apparent ileal digestibility of the dry matter, starch and protein was as average 63.9%, 93.9% and 75.4%, respectively (*Table 2*). The average DM ileal digestibility agreed with that obtained by Svihus and Gullord (2002), although there were lower differences among samples. In the same way, the average ileal digestibility of starch and protein were similar to that obtained by Meng *et al.* (2004) (93 and 73%, respectively) using a diet with 60% of wheat. Weurding *et al.* (2001) obtained also an ileal starch digestibility of 94.4% at terminal ileum for a wheat sample that contained 617 g of starch/kg.

In this trial, differences in ileal digestibility due to wheat samples were high (maximum differences of 7.2% for dry matter, 4.7% for starch and 4.4% for protein). However, no statistical differences among them were reached because of the high variability of the results (SEM from 1.29 to 1.62) and the low number of replicates. Svihus and Gullord (2002) failed to find statistical effect of wheat cultivar on ileal digestibility and AME. Skiba *et al.* (2003) found similar ileal starch digestibilities with maximum differences of 5.7% in starch digestibility among wheat samples.

**Table 2 DM, starch and protein ileal digestibilities (%) of wheat based diets for broilers (27 to 30 d of age)**

Wheat diet	Dry matter	Starch	Protein
Casarrubios	64.7	95.3	74.7
Griñón	65.5	95.0	76.9
Murcia	60.8	90.8	73.5
Reus	63.5	92.6	75.0
Sevilla	64.5	95.2	76.7
Mean	63.9	93.9	75.4
SEM	1.62	1.35	1.29
P =	0.325	0.107	0.309

The faecal dry matter and starch digestibility were as average 63.4% and 92.9%, respectively (*Table 3*), and the average protein retention was 48.9%. Significant ( $P = 0.03$ ) differences were reached for dry matter digestibility and tendencies ( $P = 0.06$ ) were observed for protein retention. Data from the literature of total tract starch digestibility agreed with our values, for example Carré *et al.* (2005), studying 15 different wheat samples obtained an average total tract starch digestibility of 93.5% (ranged from 89.4 to 96.3%).

Digestibility of the dry matter and of the starch were similar at the ileal and at the faecal level (*Table 2 and 3*). This seems to indicate that no further digestion of the starch occurs after the ileum, in the caeca, as was previously observed by Yutste *et al.* (1991) and Weurding (2002). To our knowledge, there is no clear evidence on why starch is not utilised in the hindgut. Three explanations can be hypothesized; a) the feed retention time is not long enough to allow the starch fermentation by the microbiota; b) the starch is not entering the caeca or c) in the caeca there is no amylolytic enzymes and thus starch cannot be utilised. Shires *et al.* (1987) determined that the feed stayed 23% of the total time in the hindgut compared to the 45% that stayed in the small intestine. This seems to indicate that the feed enters the hindgut at stays there relatively long enough to be used. However, the trial was done on corn-canola and corn-soya based diets and results of retention time has to be extrapolated carefully to wheat diets. On the other hand, the ileal protein digestibility values obtained in the current

work agreed with those obtained by Carré *et al.* (2005) at faecal level (from 74 to 77%) in the study mentioned above. This might indicate no protein digestion by microbiota in the hindgut of broilers.

Wheat protein content was negatively correlated with starch content ( $r = -0.85$ ,  $P < 0.06$ ) and starch digestibility ( $r = -0.95$  and  $-0.86$  at ileal and faecal level, respectively,  $P = 0.05$ ). The starch granules of the cereals' endosperm are embedded in a protein matrix (Lásztity, 1984) which strongly interacts with the starch granules (Barlow *et al.*, 1973) and provides hardness to the wheat. Carré *et al.* (2005) found a positive relationship between protein content and hardness of the wheat and a negative relationship between hardness of the wheat and starch digestibility. It may be that the amount of protein, together with the degree of interaction between the endosperm protein and starch plays a role on the different starch digestibilities of the wheats.

**Table 3 DM and starch faecal digestibilities (%), protein retention (%) and energy value (kcal/kg DM) of wheat based diets for broilers (27 to 30 d of age)**

Wheat diet	Dry matter	Starch	Protein retention	AME <sup>1</sup>	AMEn <sup>2</sup>
Casarrubios	63.4 <sup>ab</sup>	93.2	47.9	2974	2840
Griñón	66.2 <sup>a</sup>	95.2	52.2	3100	2952
Murcia	60.4 <sup>b</sup>	90.0	45.9	2889	2741
Reus	64.2 <sup>a</sup>	92.2	48.9	3011	2857
Sevilla	64.1 <sup>a</sup>	93.4	49.8	3026	2874
Mean	63.4	92.9	48.9	3001	2854
SEM	1.13	1.47	1.14	47.35	44.86
P =	0.03	0.233	0.068	0.070	0.058

<sup>1</sup> Apparent metabolisable energy, <sup>2</sup> Apparent metabolisable energy zero nitrogen retention

Apparent metabolisable energy of the diets is shown in Table 3. Average values were 3001 kcal/kg DM for AME and 2854 kcal/kg DM when AME was corrected by zero nitrogen retention. Both energy values and faecal digestibility agreed with data obtained by Juanpere *et al.* (2005) using 70% of wheat in a diet non-enzyme supplemented. The effect of wheat samples on dietary energy value (ranged from 2740 to 2950 kcal AMEn/kg DM) tended to be significant ( $P = 0.07$  for AME and  $P = 0.05$  for AMEn). The differences in AMEn of the diets were positively related to faecal starch digestibility ( $r = 0.96$ ), ileal protein digestibility ( $r = 0.91$ ) and to protein retention ( $r = 0.98$ ).

**Table 4 Energy value (mean ± standard error) of the wheat samples calculated as difference of a basal diet**

Wheat sample	AME <sup>1</sup> (kcal/kg DM)	AMEn <sup>2</sup> (kcal/kg DM)
Casarrubios	3165 ± 44.74 <sup>3</sup>	3075 ± 38.19
Griñón	3300 ± 60.39	3197 ± 54.43
Murcia	3075 ± 67.36	2968 ± 54.00
Reus	3205 ± 97.22	3095 ± 85.33
Sevilla	3221 ± 61.51	3112 ± 57.62

<sup>1</sup> Apparent metabolisable energy, <sup>2</sup> Apparent metabolisable energy zero nitrogen retention, <sup>3</sup> Standard error, calculated according to Villamide (1996)

Table 4 shows the AME and AMEn values of the different wheat samples estimated from the experimental diets. Average AMEn value was 3089 kcal/kg DM. This value is 231 kcal lower than the AMEn reported by INRA-AFZ table (3320 kcal/kg DM, Sauvant *et al.*, 2002) and 234 kcal lower than the AMEn reported by CVB table (3323 kcal/kg DM, Centraal Veevoerbureau, 2002). The sample coming from Murcia showed the lowest AME and AMEn (3075 and 2968 kcal/kg DM, respectively) while the one coming from Griñón showed the highest AME and AMEn (3300 and 3197 kcal/kg DM). The wheats coming from Casarrubios, Reus and Sevilla showed intermediate values (3197 and 3094 kcal/kg DM as average). The differences found in the energy value of wheat samples in the current work were of the same magnitude of that found by Carré *et al.* (2005) if dietary differences (144 kcal/kg DM) are assigned to wheat (261 kcal/kg DM), but lower than that obtained by Svihus and Gullord (2002). The AMEn of wheat samples were positively related with faecal digestibility of starch ( $r = 0.96$ ,  $P < 0.05$ ), and negatively with protein content ( $r = -0.70$ ,  $P < 0.05$ ). Sixty per cent of wheat AMEn variability was explained by the variation in the digestible starch content.

From this trial we can conclude that the AMEn of the wheat samples varied considerably. This variation was mainly explained by the digestible starch content, and was negatively related to wheat protein content. Although ileal starch digestion was incomplete, no further starch digestion occurred in the caeca.

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