Effects of diet particle size on digestive parameters in D^+ and D^- chicken lines selected for divergent digestion efficiency

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ABSTRACT

The experiment aimed at studying the effects of diet particle sizes in the D^+ and D^- genetic lines selected on divergent digestion efficiency. The effect of diet particle size was investigated by testing a "S" Standard pelleted diet (maize/soybean starter diet), a "H" Hull pelleted diet (S diet diluted with 7% coarse cereal hull) and a "C" Coarse diet (the "S" diet distributed as 30% coarsely crushed maize and 70% remaining part as pellets). Interactions were observed between diet and line for gain:feed ratio (7 to 20 d), AMEn (20 to 23 d), and [measured AMEn:calculated AMEn] ratio (20 to 23 d). Gain:feed ratio (7 to 20 d) decreased with Coarse and Hull diets for D^+ chickens, whereas there was no diet effect for D^- line. Digestion efficiency assessed by the [measured AMEn:calculated AMEn] ratio was improved in D^- chickens fed with the Coarse and Hull diets compared to the Standard diet, while it remained the same for all diets in D^+ chickens. Independently of the diet, gizzard and pancreas were heavier, and intestine was lighter in D^+ line compared to D^-. Within both genetic lines, the relative weight of gizzard and pancreas increased with the Coarse and Hull diets.

Keywords: chicken; genetics; particle size; digestive organs; metabolizable energy

Introduction

Wheat is a major feed ingredient for poultry, but its digestion is highly variable among broiler chickens. This variability is partly linked to individuals. Thus, the broiler chicken genetic divergent lines D^+ (good digesters) and D^- (bad digesters) were created. These two genetic lines were selected on the digestion efficiency assessed by Apparent Metabolizable Energy values corrected to zero nitrogen-retention (AMEn) of a wheat-based diet measured at 3 weeks of age (Mignon-Grasteau *et al.*, 2004).

This experiment was based on D^+ and D^- chickens from the sixth generation, with about 30% difference in AMEn values of wheat diet.

The aim of this study was to assess and understand the physiological limiting factors of digestion in each genetic line. We focused on several of the anatomical responses to diets associated with digestion efficiency.

Material and methods

Chicks were fed ad libitum with a commercial starter diet (3100 Kcal/kg AMEn, 22% CP) until 7 days. Then, they were given one of the 3 experimental diets: a "S" Standard pelleted diet containing 58.26% maize and 33.4% soybean meal; a "H" Hull pelleted diet composed as the "S" diet diluted with 7% coarse cereal hull from oat and wheat, and a "C" Coarse diet identical to the "S" diet,

distributed as 30% coarsely crushed maize and 70% remaining part as pellets. The actual proportions of crushed maize consumed from day 20 to 23 were measured for each bird and were not significantly different between the two lines D^+ and D^- (19.8±2.68% and 22.1±2.16 %, respectively). A build up of uneaten coarsely ground maize lead to a relative increase in pellets consumption, and thereby a higher protein concentration of the diet (24,4% in the chosen mixture versus 22.7% in the distributed diet). However, the total maize consumption (maize in the pellets + ground maize) remained the same independent of the quantity of coarsely crushed maize eaten.

The experiment was carried out on 81 broilers (male or female) from each of the divergent lines D^+ and D^- (6^{th} generation). The experimental design consisted in 6 experimental treatments (2 lines x 3 dietary treatments), with 27 individual replicates per treatment. On day 7, the chickens were randomly allocated to individual cages placed in three identical ventilated rooms with controlled light and temperature. All birds were weighed on days 7 and 20, and individual feed consumptions were measured between days 7 and 20. A balance experiment was conducted from days 20 to 23, using the method of total excreta collection.

On day 26, 20 individual replicates from each of the 6 experimental treatments were randomly selected for dissection. Chicks were individually weighed, then euthanized by intracardiac injection of pentobarbital. Gizzard, small intestine, and pancreas were immediately isolated, emptied, and weighed.

Results and discussion

Body weights in D^- were 15% higher than in D^+ at 7 and 20d (Table 1). An interaction between diet and genetic lines was observed for gain:feed ratio (7 to 20 d): paradoxically, no significant differences were found between diets with D^- chickens, whereas, with D^+ line, gain:feed ratio was higher ($P<0.0001$) for chickens fed with the Standard diet compared to Coarse and Hull diets. The AMEn values were higher for D^+ line. The [measured AMEn /calculated AMEn] ratio was considered in order to remove the effects due to variation in diet composition. Thus, this ratio could be ascribed to the digestion efficiency for the potentially available components (starch, protein, lipid, sugars). The ratio was improved for D^- chickens fed the Coarse or Hull diets as compared to the Standard diet, while this improvement was not observed in D^+. Within D^+ line, the ratio for H diet was significantly greater than the C diet.

Table 1 Effects of diets on growth performances (7 to 20 d), AMEn (20 to 23 d) and [measured AMEn /calculated AMEn[1]] ratio in broilers from the genetic lines D^+ and D^-, differing in digestive efficiency. The S diet was a pelleted maize-based diet, the H pelleted diet was the S diet diluted with 7% cereal hull, and the C diet was the S diet, with 30% presented as coarsely crushed corn, and 70% as pellets.

Genotype	Diet	BW (g) 7 d	BW (g) 20 d	Feed intake[2] (g) (7 to 20 d)	Gain:feed (7 to 20 d)	AMEn (20to 23 d) (Kcal/kg)	Measured AMEn/ calculated AMEn[1]
D^+ line	S	95.6	388.3	402.9	0.73^{c}	3343^{d}	0.994^{de}
D^+ line	H	101.1	377.6	429.7	0.65^{ab}	3166^{b}	1.005^{e}
D^+ line	C	96.9	375.1	418.5	0.67^{b}	3271^{c}	0.990^{cd}
D^- line	S	112.6	440.9	515.8	0.64^{ab}	3140^{b}	0.934^{a}
D^- line	H	114.9	438.4	519.2	0.62^{a}	3080^{a}	0.977^{bc}
D^- line	C	114.1	427.9	497.1	0.63^{a}	3221^{c}	0.971^{b}
SEM[3]		2.87	11.69	13.38	0.0115	19	0.0051
Effects							
Line		***	***	***	***	***	***
Diet		NS	NS	NS	***	***	***
Line x diet		NS	NS	NS	*	**	**

[1]Calculated AMEn= 0.9362GE-15.38CP(%)-25.16WICW[1,2](%), (Carré and Rozo, 1990)
[2]Dry matter basis
[3]Pooled standard error of means with 27 individual replicates per treatment
[a,b,c]Means with different letters within columns are significantly different ($p<0.05$)

Relative weights of digestive organs on day 26 are reported in Table 2. Gizzard and pancreas were significantly larger in D^+ chickens than in D^- ones. On the contrary, small intestine was bigger in D^- birds, independently of the diet, which may be an indication of an adaptation process in D^- compensating poor digestion. In our study, both coarse diets (H and C diets) induced an increase in the gizzard and pancreas relative weights. Previous studies also reported the positive effect of coarse particles or whole cereal grains on the gizzard weight (Svihus *et al.*, 2001; Hetland *et al.*, 2002).

Table 2 Effects of diets on digestive organs weight of 26-d-old broiler chickens from D^+ and D^- lines, genetic lines differing in digestive efficiency. S diet= pelleted maize-based diet; H diet= S diet diluted with 7% cereal hull, pelleted; C diet = S diet, with 30% presented as coarsely crushed corn, and 70% as pellets.

Genotype	Diet	Gizzard weight (mg/g BW)	Pancreas weight (mg/g BW)	Small intestine weight (mg/g BW)	Gizzard weight/ intestine weight (g/g)
D^+ line	S	21.2	2.9	36.1	0.59
D^+ line	H	29.1	3.2	37.8	0.77
D^+ line	C	26.9	3.2	38.1	0.71
D^- line	S	16.8	2.6	42.6	0.40
D^- line	H	25.3	2.9	41.3	0.63
D^- line	C	22.7	2.9	39.8	0.58
SEM[1]		0.72	0.12	1.33	0.021
Effects					
Line		***	*	**	***
Diet		***	*	NS	***
Line x diet		NS	NS	NS	NS

[1]Pooled standard error of means with 20 individual replicates per treatment

The overall variation in digestion efficiency among lines and diets was positively related to gizzard and pancreas weights (Figures 1 and 2). This suggests that these two organs were strongly involved in the digestion variations. So, gizzard and pancreas functions and their regulations would be less developed in D^- than in D^+; stimulation by coarse particles would help D^- birds in the development of the gizzard and pancreas functions.

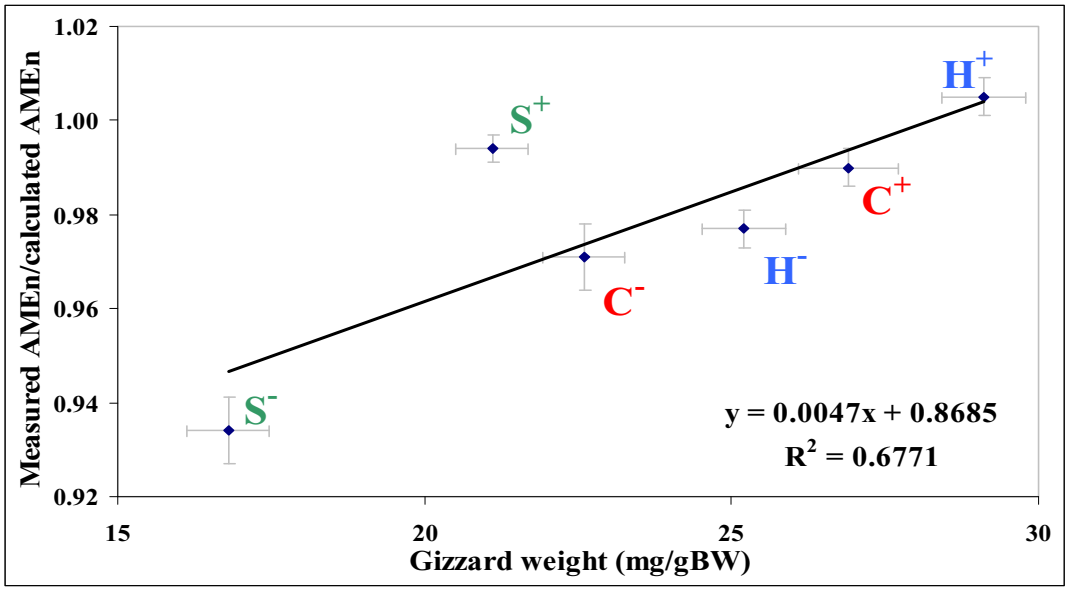

Figure 1 Relationship between relative gizzard weight and digestion efficiency (expressed by the ratio AMEn measured/AMEn calculated) ; "S"= Standard diet, "H"=Hull diet, "C"=Coarse diet, "+"= D^+ line, "-"=D^- line

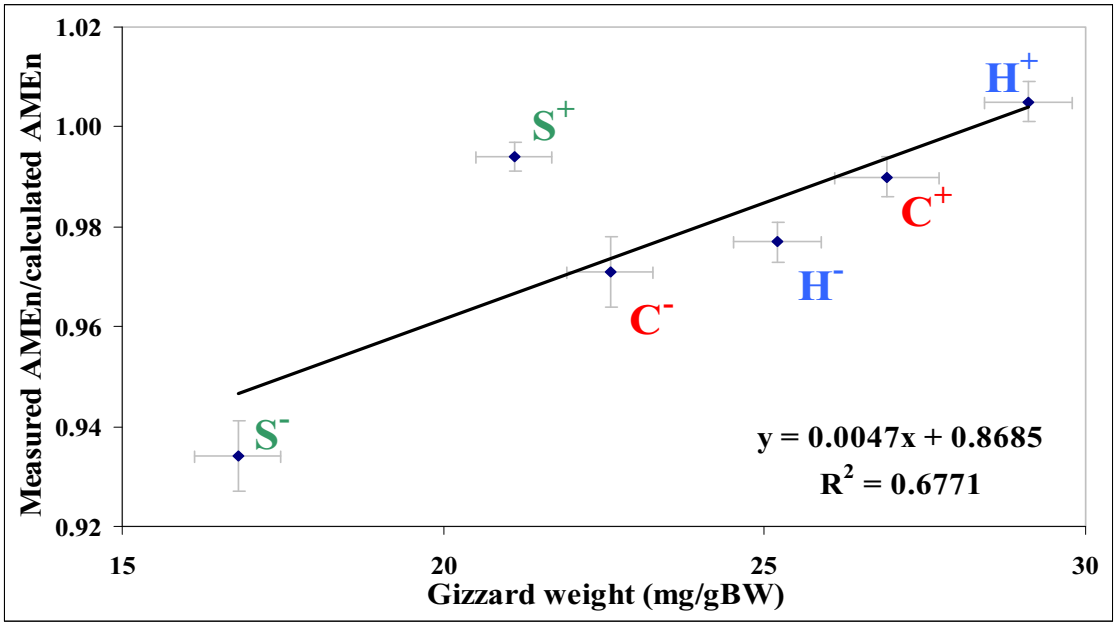

Figure 2 Relationship between relative pancreas weight and digestion efficiency; "S"= Standard diet, "H"=Hull diet, "C"=Coarse diet, "+"= D^+ line, "-"=D^- line

In conclusion, with a maize diet, D^- chicks needed a stimulus by coarse particles for reaching optimum digestion. In contrast, this stimulus was not needed by D^+ birds, whose digestion remain high whatever the granulometry of the diet. Thus, including coarse particles in the diet could improve the digestion of poor digestion efficiency capacity birds. Part of this improvement could be due to an enhancement of starch digestibility, as reported Svihus and Hetland (2001) when whole wheat (38.5%) was included in the diet. This study could assess part of the physiological limits of digestion by D^- chickens.

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