Effects of Pelleting, Lactose Level, Polyethylene Glycol 4000, and Guar Gum Compared to Pectin on Growth Performances, Energy Values, and Losses of Lactose, Lactic Acid, and Water in Chickens

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ABSTRACT Five mash and two pelleted diets were tested in broiler chickens (7 to 19 d). Mash diets consisted of a basal fraction diluted with either .5% pectin or .5% guar gum. Mash pectin and guar gum diets contained either 3% lactose (PL_3m and GL_3m diets, respectively) or 6% lactose (PL_6m and GL_6m diets, respectively). Compositions of pelleted diets (PL_3p and GL_3p) were those of PL_3m and GL_3m diets, respectively. All diets contained .5% polyethylene glycol 4000 (PEG) except the PL_3m_0 diet. The latter diet differed from PL_3m diet by the PEG content, only. The real applied viscosities of pectin and guar gum diets were 1.48 and 4.94 mL/g, respectively. No effect of PEG was detected on growth performances, and excreta losses of lactose, lactic acid, and water. No negative effect of guar gum compared to pectin was observed on body weight (19 d), except with pelleted diets ($P < .05$). Feed:gain ratios for guar gum diets were 7% higher ($P \leq .002$) than those of pectin diets. The AME_n values of guar gum diets were 4% lower ($P \leq .001$) than those of pectin diets. For mash diets, lactose digestibilities were lower ($P < .05$) with guar gum than with pectin. Increasing lactose level from 3 to 6% did not affect ($P > .05$) AME_n values, feed: gain ratios, and body weights (19 d) but reduced ($P = .001$) lactose digestibilities from 78 to 64%. The positive effects of pelleting on body weights (19 d) were much less pronounced with guar gum than with pectin ($P < .05$). The AME_n values of pelleted diets (PL_3p and GL_3p) were, on average, 2.5% lower ($P = .005$) than their mash counterparts (PL_3m and GL_3m). Water losses related to feed intake were greater with guar gum than with pectin ($P < .001$) and with 6% lactose than with 3% ($P = .001$), but were not affected ($P > .05$) by pelleting. Lactic acid losses related to feed intake were increased by guar gum compared with pectin ($P < .001$), with more pronounced effects induced by high lactose level ($P < .05$) and pelleting ($P < .05$). In many respects, the effects of guar gum seemed similar to those observed in an acid liquid diarrhea.

(*Key words*: viscosity, lactose, growth, lactic acid, chicken)

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INTRODUCTION

The negative effects of viscous polysaccharides on growth performances in chickens have already been clearly identified (Rickes *et al.*, 1962; Burnett, 1966; Blum *et al.*, 1980; Bedford and Classen, 1992). Sticky or wet droppings have also been associated with viscous polysaccharides (Moran *et al.*, 1969; Gohl *et al.*, 1978). These negative effects are probably mediated in part by reductions in nutrient digestibilities (Moran *et al.*, 1969; Marquardt *et al.*,

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1979; Classen *et al.*, 1985). Viscosity likely acts by reducing enzyme activities (Ikeda and Kusano, 1983; Dutta and Hlasko, 1985) and absorption efficiencies (Johnson and Gee, 1981; Lund *et al.*, 1989).

The improvements observed with antibiotics added in diets high in viscous polysaccharides (Moran and McGinnis, 1965; Marquardt *et al.*, 1979) suggest that microflora play a role in the effect of viscosity. However, the mechanisms involved in this possible role have not been elucidated. Pelleting may also reduce the negative effects of viscous polysaccharides, as observed with barley (Arscott *et al.*, 1958) or rye (Moran *et al.*, 1969) diets. However, pelleting was also observed to induce little or no effect with rye diets (Misir and Marquardt, 1978; Bedford *et al.*, 1991). The significance of pelleting rye or barley diets remains unclear, as pelleting effects may depend on energy concentration and possible denaturation of natural enzymes by heat (Carré *et al.*, 1994; Inborr and Bedford, 1994). Therefore, variabilities in responses to pelleting observed in the literature may be due to uncontrolled factors such as energy values and activities of natural enzymes.

The present experiment was designed to investigate the role of microflora by studying the effects of dietary viscosity and lactose level on lactose digestibility, lactic acid losses, and water losses. Lactose can be digested only by bacterial fermentation in chickens, as there is no endogenous lactase in their intestine (Siddons and Coates, 1972). The effects of pelleting were also tested. Purified polysaccharides (pectin and guar gum) were used to test effects of viscosity, which allowed us to formulate isoenergetic diets and to avoid interactions with the polysaccharide hydrolyzing enzymes that could be present in ingredients of diets. Metabolizable energy values and growth performances were controlled. The experiment also tested the suitability of polyethylene glycol 4000 (PEG) for its use as an inert marker.

MATERIALS AND METHODS

Forty-eight 1-d-old male broiler chickens (Ross) were put in metal cages (30 cm length, 30 cm width, 36 cm height) placed in a ventilated room with 23 h light/d. Temperature was 30 C until 7 d, 28 C until 14 d, and 24 C until 22 d. Birds were fed a basal fraction (Table 1) diluted with 3% lactose and .5% PEG until 7 d. Then they were divided into seven groups of similar mean weight, with seven birds per group except for the group (six birds) allocated to the PL_3m_0 diet. From 7 d, each group was fed one of the seven experimental diets (Table 2) with birds kept in individual cages.

TABLE 1. Composition of the basal fraction used in experimental diets

Ingredients	Basal fraction
	(%)
Corn	66.50
Soybean protein isolate[1]	12.00
Sunflower meal	10.00
Meat meal	5.00
Canola oil	4.00
DL-methionine	.10
Sodium chloride	.35
Calcium carbonate	.60
Dicalcium phosphate	.80
Vitamin supplement[2]	.50
Mineral supplement[3]	.10
Robenidine[4]	.05

[1] Ardex® F dispersible; Société Industrielle des Oléagineux, 62053 Saint-Laurent-Blangy, France.

[2] Supplies per kilogram of basal fraction: vitamin A (all-*trans*-retinol), 10,000 IU; cholecalciferol, 1,500 IU; vitamin E (dl-α-tocopheryl acetate), 15 mg; butylated hydroxy toluene, 125 mg; menadione, 5 mg; thiamine, .5 mg; riboflavin, 4 mg; calcium pantothenate, 8 mg; niacin, 25 mg; pyridoxine, 1 mg; vitamin B_{12}, .008 mg; folic acid, 1 mg; biotin, .2 mg; choline chloride, 750 mg.

[3] Supplies, in milligrams per kilogram of basal fraction: Co, .33; Cu, 8.7; I, 1.2; Se, .2; Zn, 84; Fe, 44; Mn, 106.

[4] Robenz, American Cyanamid Co., Agricultural Division, Wayne, NJ 07470.

Four experimental diets (PL_3m, GL_3m, PL_6m, GL_6m) (Table 2) among the seven were designed as a 2 × 2 factorial arrangement with two polysaccharides differing in viscosity (pectin and guar gum) and two dietary levels of lactose (3 and 6%). The latter four diets were given as mash. Two other diets (PL_3p and GL_3p) (Table 2) were the pelleted form of the two previous mash diets containing 3% lactose

(PL_3m and GL_3m). Considering the combination of Diets PL_3p, GL_3p, PL_3m, and GL_3m, another 2 x 2 factorial arrangement was obtained with two polysaccharides (pectin and guar gum) and two forms of diet presentation (mash and pellet). Another diet (PL_3m_0) (Table 2) was also given that differed from PL_3m diet only by the PEG content, with 0 and .5% PEG in PL_3m_0 and PL_3m diets, respectively. Comparison of the two latter diets allowed us to test the effects of PEG. All diets contained .5% PEG except PL_3m_0 diet.

The relative viscosities (η_r) (ratio of the viscosity of polysaccharide in buffer to the viscosity of buffer) of .5 g of guar gum, pectin and PEG in 1 L of acetate buffer (.2 *M*, pH 4.5) were 1.602, 1.138, and 1.008, respectively. The latter viscosity measurements[2] were performed at 22 C in the decreasing shear rate range of 25 to 800 per second. Therefore, the applied viscosities [Ln (η_r)/grams per milliliter] (Carré *et al.*, 1994) of guar gum, pectin, and PEG were 943, 258, and 15 mL/g, respectively. The applied viscosities supplied by the introduction of .5% of the latter components in the experimental diets were 4.72, 1.29, and .07 mL/g, respectively. The measured real (extraction at pH 4.5, 1 h, 22 C; Carré *et al.*, 1994) applied viscosities of guar gum and pectin diets were 4.94 and 1.48 mL/g, respectively, with no noticeable differences due to lactose, PEG, or pelleting.

Birds were weighed at 7 and 19 d, with their individual feed intake being recorded between these times. Birds had free access to feed and water until 19 d. A digestion balance experiment was performed from 19 d to 22 d. This consisted in a feed deprivation of 18 h, followed by 54 h with *ad libitum* access to feed, and 18 h final feed deprivation. Birds had free access to water throughout the balance experiment. Individual feed intakes were measured and excreta were collected individually twice daily for the feeding and the last feed deprivation periods. Excreta were weighed and immediately stored at –20 C after each collection. Birds were weighed at the end of each deprivation period. Excreta were freeze-dried, weighed, ground through a .5-mm screen, and stored in a sealed plastic bag at 4 C until analyses. Excreta losses of water were measured as the losses of weight following freeze-drying of excreta.

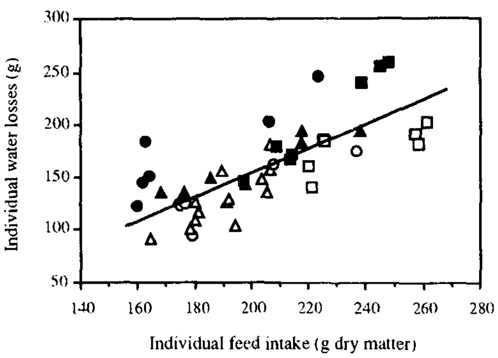

FIGURE 1. Individual water losses (y) and feed intakes (x) measured for the balance experiment. Y = 1.12x - 66 (R^2 = .55). ▲ = GL_3m △ = PL_3m + PL_3m_0; ● = GL_6m; ○ = PL_6m; ■ = GL_3p; □ = PL_3p diet. Residues of the regression line differed (*P* = .0001) between diets.

Polyethylene glycol was measured in feed and freeze-dried excreta using a turbidimetric analysis (Malawer and Powel, 1967). Measurements of polyethylene glycol in freeze-dried excreta were determined only for diets PL_3m, PL_3p, GL_3m, and GL_3p. Lactic acid and lactose were measured enzymatically in feed and freeze-dried excreta as described by Carré *et al.* (1995). Gross energy values of feed and freeze-dried excreta were measured using an isoperibol calorimeter[3] maintained in a room at 22 to 25 C. The AME_n were calculated with the nitrogen correction being based on weight gain measured during the balance experiment (Bourdillon *et al.*, 1990).

Statistical Analysis

Data were analyzed by analyses of variance using General Linear Models performed with the SYSTAT® software program.[4] One-way analyses of variance

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[2] Rheomat 115 A Contraves rheoanalyzer. Sté Lamy, 69300 Caluire, France.

[3] IKA-Kalorimeter C 700, IKA-Analysentechnik GmbH, 7843 Heitersheim Grissheimer Weg 5, Germany.

[4] Wilkinson, Leland Systat Inc., Evanston, IL 60201.

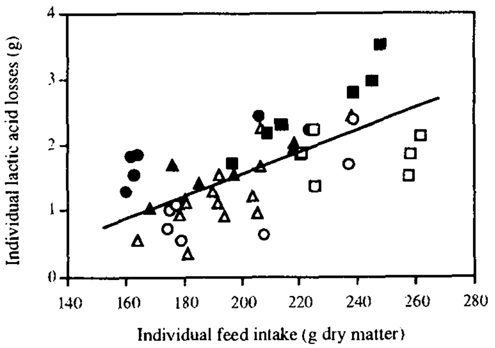

FIGURE 2. Individual lactic acid losses (y) and feed intakes (x) measured for the balance experiment. Y = .0151x – 1.44 (R^2 = .39). ▲ = GL_3m △ = PL_3m + PL_3m_0; ● = GL_6m; ○ = PL_6m; ■ = GL_3p; □ = PL_3p diet. Residues of the regression line differed (P = .0001) between diets.

were performed for testing the effect of diets on PEG recovery and for testing the effect of PEG addition (PL_3m vs PL_3m_0) on growth performances and digestibility results. When the effects of PEG were not significant (P > .05), the individual data from Diets PL_3m and PL_3m_0 were combined within one set of data for performing the two-way analyses of variance. Two-way analyses of variance were applied for the four mash diets (PL_3m, GL_3m, PL_6m, GL_6m) to test the effects of type of polysaccharide and lactose level. Two-way analyses of variance were also applied for the four diets containing 3% lactose (PL_3m, GL_3m, PL_3p, GL_3p) to test the effects of pelleting and type of polysaccharide.

All the individual values of water excretions (w_i) observed with the seven diets were pooled and related to individual feed intakes (f_i) by a regression calculation (Figure 1), and the individual residual values from the regression line ($wr_i = w_i - 1.12 f_i + 66$) were calculated. Then, mean residual values for each diet were calculated. The same calculations were performed for lactic acid excretions in relation to feed intakes (Figure 2).

RESULTS

The mean value for PEG recoveries was .970 with no effect of diets (Table 3). No effects were observed with PEG addition except for the feed intake during the balance experiment (P = .015) and for amounts of lactic acid excreted (P = .032) (Table 4). However, lactic acid excretions analyzed as the residues of the regression line based on feed intake (Figure 2) did not differ (P > .05) between PL_3m and PL_3m_0 diets (Table 4).

With mash diets, body weights at 19 d were not affected by type of polysaccharide or by lactose level (Table 5). For mash diets, the feed:gain ratios were the highest with guar gum diets (P = .002) and were not affected by lactose level (Table 5).

Guar gum addition in mash diets resulted in lower AME_n values than pectin addition (P = .001) (Table 5). Lactose level

TABLE 2. Composition of experimental diets

	Diet						
Ingredients	PL_3m_0	PL_3m	GL_3m	PL_6m	GL_6m	PL_3p	GL_3p
	(%)						
Basal fraction	96.5	96.0	96.0	93.0	93.0	96.0	96.0
Pectin[1]	.5	.5	0	.5	0	.5	0
Guar gum[2]	0	0	.5	0	.5	0	.5
Lactose[3]	3.0	3.0	3.0	6.0	6.0	3.0	3.0
PEG[4]	0	.5	.5	.5	.5	.5	.5
Presentation	Mash	Mash	Mash	Mash	Mash	Pellet	Pellet

[1] 50 to 60% methylation degree, Sanofi Bio-Industries, 75008 Paris, France.

[2] Sigma Chemical Co., St. Louis, MO 63178-9916.

[3] Roussel Uclaf, 93230 Romainville, France.

[4] Polyethylene glycol 4000, ground on .5-mm sieve, Prolabo, 75011 Paris, France.

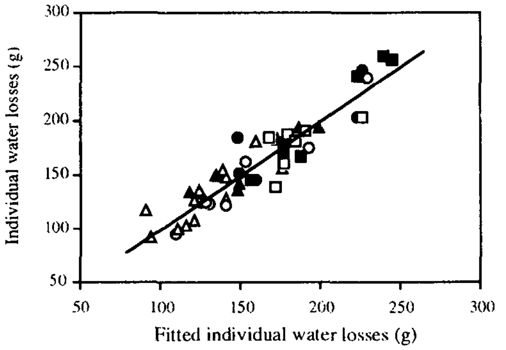

FIGURE 3. Individual water losses (y) measured for the balance experiment. Fitted values (x) were calculated with the following multiple regression line: $y = .475\ x_1 + 36.6\ x_2 + 7.0\ x_3 - 12$ ($R^2 = .86$), where x_1 = individual feed intakes (grams of dry matter); x_2 = individual lactic acid losses (grams); x_3 = individual lactose losses (grams). ▲ = GL_3m △ = PL_3m + PL_3m_0; ● = GL_6m; ○ = PL_6m; ■ = GL_3p; □ = PL_3p diet. Residues of the regression line did not differ between diets.

did not change AME_n values (Table 5). With mash diets, a significant effect (P = .041) of polysaccharide type on lactose digestibility was detected, the lowest values being observed with guar gum diets (Table 5). Increasing lactose level from 3 to 6% resulted in a marked decrease in lactose digestibility (P = .001) (Table 5).

Residual water (Figure 1) and lactic acid excretions (Figure 2) observed for mash diets were the greatest with guar gum diets (P < .001) (Table 5). The effect of guar gum on residual lactic acid excretion (Figure 2) was greater with the 6% lactose diets (polysaccharide type by lactose level interaction: P = .03; Table 5). The residual water excretions (Figure 1) were significantly greater for the 6% lactose level compared to 3% (P = .001) (Table 5).

Pelleting induced beneficial effects (P < .001) on feed:gain ratios and body weights at 19 d (Table 6). The latter effect was much less pronounced for guar gum diets than for pectin diets (polysaccharide type by pelleting interaction: P = .042; Table 6). Pelleting resulted in a decrease of AME_n values (P = .005) (Table 6).

Residual water excretions (Figure 1) were not affected by pelleting (Table 6). The effect of polysaccharide type on residual lactic acid excretions (Figure 2) was the most pronounced with pelleted diets (polysaccharide type by pelleting interaction: P = .049; Table 6).

Individual water excretions were calculated as a function combining feed intake, lactic acid excretion, and lactose excretion, using multiple linear regression calculation (Figure 3). The R^2 value was .86 and the residues did not differ between diets. All the coefficients were positive and highly significant (P = .0001).

DISCUSSION

Excreta recoveries of PEG measured after a long-term (19 d) PEG adaptation were close to 1 (Table 3), which shows that PEG was not degraded in the chicken digestive tract. Moreover, .5% PEG addition induced no effects on growth performance, AME_n value, or water losses (Table 4). Therefore, .5% PEG can be considered an inert marker of the liquid phase of digesta in chickens, as already considered for ruminants (Sperber *et al.*, 1953) and humans (Andersen *et al.*, 1988). The only effect of PEG addition consisted in a higher feed intake observed during the balance experiment (Table 4), which might explain the slight tendency for AME_n to be lowered (P = .0726; Table 4) by PEG. However, feed intake was not affected by PEG during the growth experiment (Table 4). The PEG effect observed on lactic acid excretion was due to feed intake, because this effect no longer appeared when the residual lactic acid excretions (Figure 2) were considered (Table 4).

TABLE 3. Excreta recovery of polyethylene glycol 4000 (PEG)

Diet	Excreta recovery of PEG
PL_3m	.934
PL_3p	.988
GL_3m	.995
GL_3p	.964
Pooled SEM	.0314
Source of variation	Probability
Diet	.516

The regression lines expressing water excretion (Figure 1) and lactic acid excretion (Figure 2) as functions of feed intake displayed negative ($P < .05$) intercepts. Therefore, the ratios of water excretion and lactic acid excretion to feed intake increased with feed intake increment. Accordingly, considering the latter ratios would have been questionable, as feed intakes varied between diets. For this reason, residual values from the regression lines based on feed intake were preferred instead of the ratios to feed intake.

The effects of guar gum compared to pectin on feed:gain ratios and AME_n values (Tables 5 and 6) were in agreement with those observed by Kratzer *et al.* (1967). However, the guar gum content was much lower in the present study (.5%) than in the study performed by Kratzer *et al.* (1967) (2%). The applied viscosities supplied by the introduction of .5% pectin and guar gum would correspond to those supplied by about 40% wheat and barley, respectively, introduced in pelleted (> 90 C outlet temperature) diets (Carré *et al.*, 1994). Therefore, in terms of viscosity, the present experiment was close to conditions that could be encountered in practice, whereas the experiment performed by Kratzer *et al.* (1967) corresponded probably to much higher viscosities.

The effects of guar gum compared to pectin on growth performance, AME_n, and water excretion were similar to those obtained by feeding ingredients containing viscous polysaccharides such as rye or barley (Arscott and Rose, 1960; Leong *et al.*, 1962; Rickes *et al.*, 1962; Burnett, 1966; Moran *et al.*, 1969; Gohl *et al.*, 1978; Antoniou *et al.*, 1981; Salih *et al.*, 1991; Bedford and Classen, 1992). A great part of the increases in feed:gain ratio due to guar gum could be explained by AME_n reductions. However, other factors could be involved because, in all cases, the relative changes due to polysaccharide type were greater for feed:gain ratio than for AME_n. According to effects on body weights (Table 5 and 6), birds were able to compensate for the AME_n reductions due to guar gum with mash diets, but not with pelleted diets.

The negative effect of pelleting on AME_n values (Table 6) was rather surprising, as a reverse effect is generally observed (Carré *et al.*, 1984). However, the latter effect seemed to be emphasized by the guar gum diet. In this connection,

TABLE 4. Effects of polyethylene glycol 4000 (PEG) on growth performances, AME_n values, lactose digestibility, and excreta losses of lactic acid and water

	Diet			Probability
Variable	PL_3m	PL_3m_0	Residual SD	PEG
Body weight at 7 d, g	137	136	6.7	.7974
Body weight at 19 d, g	500	475	40.0	.2757
Feed intake (7 to 19 d), g	648	604[1]	48.8	.1277
Feed:gain ratio (7 to 19 d), g:g	1.80	1.78[1]	.072	.7751
Feed intake (dry matter) for balance experiment, g	198	181	10.2	.0146
AME_n value, kcal/kg dry matter	3,359	3,433[1]	67	.0726
Lactose digestibility, g:g	.82	.85	.083	.5939
Lactic acid excretion for balance experiment, g	1.42	.86	.409	.0323
Residual lactic acid excretion,[2] g	–.13	–.44	.370	.1634
Water excretion for balance experiment, g	141	116	23.5	.0830
Residual water excretion,[2] g	–14	–21	17.5	.5164

[1] Values are related to feed corrected with a .5% PEG addition.

[2] Values are the residues from the regression lines relating lactic acid (Figure 2) or water (Figure 1) losses to intakes of dry matter for the balance experiment.

TABLE 5. Effects of type of polysaccharide (guar gum vs pectin) and lactose level (6 vs 3%) on growth performances, AME_n values, lactose digestibility, and excreta losses of lactic acid and water, observed with mash diets

Variable	Diet				Residual SD	Probability		
	PL_3m + PL_3m_0	GL_3m	PL_6m	GL_6m		Polysaccharide type	Lactose level	Polysaccharide type × lactose level
Body weight at 7 d, g	137	136	136	134	6.3	.609	.567	.878
Body weight at 19 d, g	488	485	481	452	42.1	.299	.186	.407
Feed intake (7 to 19 d), g	628[1]	652	627	624	50.9	.557	.415	.453
Feed:gain ratio (7 to 19 d), g:g	1.79[1]	1.88	1.83	1.98	.100	.002	.065	.356
Feed intake (dry matter) for balance experiment, g	198[2]	200	198	180	24.2	.385	.293	.272
AME_n value, kcal/kg dry matter	3,395[1]	3,275	3,337	3,244	76	.001	.116	.639
Lactose digestibility, g:g	.83	.73	.67	.61	.104	.041	.001	.489
Lactic acid excretion for balance experiment, g	1.42[2]	1.73	1.16	1.87	.510	.017	.764	.337
Residual lactic acid excretion,[3] g	−.28	.15	−.39	.59	.339	.000	.195	.030
Water excretion for balance experiment, g	129	162	149	176	35.4	.028	.199	.817
Residual water excretion,[3] g	−17	5	−6	42	18.4	.000	.001	.062

[1] For PL_3m_0, values are related to feed intake corrected with an addition of .5% polyethylene glycol 4000 (PEG).

[2] Values from PL_3m_0 diet are excluded because of effects of PEG (see Table 4).

[3] Values are the residues from the regression lines relating lactic acid (Figure 2) or water (Figure 1) losses to intakes of dry matter for the balance experiment.

TABLE 6. Effects of type of polysaccharide (guar gum vs pectin) and pelleting on growth performances, AME_n values, lactose digestibility, and excreta losses of lactic acid and water, observed with 3% lactose diets

Variable	Diet				Residual SD	Probability		
	PL_3m + PL_3m_0	GL_3m	PL_3p	GL_3p		Polysaccharide type	Pelleting	Polysaccharide type × pelleting
Body weight at 7 d, g	137	136	135	135	5.6	.841	.455	.841
Body weight at 19 d, g	488	485	576	511	40.5	.023	.000	.042
Feed intake (7 to 19 d), g	628[1]	652	720	669	56.1	.507	.011	.067
Feed:gain ratio (7 to 19 d), g:g	1.79[1]	1.88	1.64	1.77	.077	.000	.000	.388
Feed intake (dry matter) for balance experiment, g	198[2]	200	239	224	19.5	.399	.000	.257
AME_n value, kcal/kg dry matter	3,395[1]	3,275	3,349	3,158	72	.000	.005	.171
Lactose digestibility, g:g	.83	.73	.68	.72	.139	.527	.103	.136
Lactic acid excretion for balance experiment, g	1.42[2]	1.73	1.83	2.53	.462	.007	.002	.274
Residual lactic acid excretion,[3] g	−.28	.15	−.34	.59	.349	.000	.134	.049
Water excretion for balance experiment, g	129[2]	162	178	203	31.5	.0136	.003	.889
Residual water excretion,[3] g	−17	5	−22	19	18.0	.000	.454	.139

[1] For PL_3m_0, values are related to feed intake corrected with an addition of .5% polyethylene glycol 4000 (PEG).

[2] Values from PL_3m_0 diet are excluded because of effects of PEG (see Table 4).

[3] Values are the residues from the regression lines relating lactic acid (Figure 2) or water (Figure 1) losses to intakes of dry matter for the balance experiment.

Francesch *et al.* (1994) also observed a reduction in AME_n with pelleting diets high in viscous polysaccharides (40% barley diets). This negative effect of pelleting could also be explained in part by the greater feed intakes observed with pelleting (Table 6). For the pectin diet, because of the pronounced effect of pelleting on feed intake, the AME_n intake (7 to 19 d) with the pelleted form exceeded largely that with the mash form (Table 6). For the guar gum diet, the AME_n intakes (7 to 19 d) observed with mash and pelleted form were very similar (Table 6). However, it may be noticed that body weights and feed:gain ratios cannot entirely be explained by the feed intakes and the AME_n values measured at 3 wk. The other factors may also be the kinetics of daily feed intakes and AME_n values from 7 to 19 d.

The increase in lactose level from 3 to 6% reduced the lactose digestibility by 14% (Table 5), which represents a rather strong effect. This shows that, even if chickens have some potential for digestion of fermentable water-soluble carbohydrates, young birds cannot digest great amounts of them. In other words, in young birds, saturation of fermentation in ceca may happen readily. Several points of the present study suggested that guar gum feeding resulted in saturations of fermentations: guar gum feeding induced reductions in lactose digestibility, that were even greater than AME_n reductions (Table 5). Moreover, lactic acid excretions were markedly increased by guar gum (Tables 5 and 6). These increases in lactic acid excretions likely came from increases in amounts of fermented nutrients (such as unabsorbed glucose available to microbes), and from reduced lactic acid absorption. Keeping in mind that ceca are major site for lactic acid absorption or metabolization, and that ceca are likely a location for lactose digestion (Carré and Gomez, 1994), it could be proposed that the saturations of cecal fermentations due to guar gum were expressed by a reduction of ceca filling.

The effects of lactose level on feed:gain ratios, AME_n values or lactic acid excretion were generally not significant or much less pronounced than those due to guar gum (Table 5). This suggests that the increases in the amount of nutrients escaping digestion before ceca were greater with the guar gum addition than with the lactose addition.

The osmotic pressure promoted by lactic acid and lactose probably explained the formulation of the regression line expressing water losses (Figure 3). In this connection, the much higher value appearing for the coefficient of lactic acid than for lactose is logical, as the molecular weight of lactic acid is about four times less than lactose.

According to the strong effect of guar gum on lactic acid excretion (Tables 5 and 6), it could be proposed that a great part of the overexcretion of water induced by guar gum was mediated by lactic acid concentration. In many respects, the effects of guar gum seemed similar to those observed in an acid liquid diarrhea.

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