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Oat hulls and sugar beet pulp in diets for broilers. 2. Effects on the development of the gastrointestinal tract and on the structure of the jejunal mucosa

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ABSTRACT

The effects of inclusion of oat hulls (OH) and sugar beet pulp (SBP) in the diet on the development of the gastrointestinal tract (GIT) were studied in broilers from 1 to 18 days (d) of age. A control diet based on rice that contained 16 g crude fibre (69 g dietary fibre)/kg was diluted with 25, 50 and 75 g of either OH or SBP/kg. Each of the seven treatments was replicated six times (a cage with 12 chicks). The weight of the digestive organs and the pH of the digesta contents were recorded at d 6, 12 and 18, and the jejunal morphology at d 12 and 18. The inclusion of a fibre source in the diet affected in different ways the development of the organs of the GIT. The relative weight of the GIT with digesta contents (g/kg body weight, BW) increased linearly (L; $P \leq 0.001$) as the level of fibre in the diet increased. The weight of the pancreas increased (L; $P \leq 0.01$ at d 6 and 12, and $P < 0.05$ at d 18) with SBP inclusion but little effect was observed with OH. The relative weight of the gizzard ($P \leq 0.001$) and its DM content was increased ($P \leq 0.001$), and gizzard pH was reduced ($P \leq 0.001$) with fibre inclusion at all ages. Broilers fed OH had heavier gizzards ($P \leq 0.001$) that had higher DM content ($P \leq 0.001$) and gizzard pH ($P < 0.05$ at d 12 and 18) than broilers fed SBP. The pH of the digesta of the duodenum increased with OH or SBP inclusion at d 6 (L; $P \leq 0.01$) and with SBP inclusion (L; $P \leq 0.01$) at d 12. Villus height at d 12 was reduced with SBP inclusion (L; $P < 0.05$) but no effects were detected with OH. We conclude that the inclusion of up to 75 g OH or SBP/kg in low fibre diets increased the relative weight of the GIT and reduced digesta pH of the gizzard. The inclusion of high levels of SBP (75 g/kg) might have detrimental effects on the structure of the jejunal mucosa. Dietary fibre stimulates the development of the GIT in young birds but an excess might hinder intestinal mucosa structure.

1. Introduction

High quality ingredients are used in diets for young chicks to reduce the incidence of enteric disorders and increase growth performance (Mateos et al., 2002). These diets contain limited amount of fibre in order to maximize voluntary feed intake and increase nutrient digestibility. However, low fibre diets might affect the structure of the mucosal epithelium

Abbreviations: BW, body weight; CF, crude fibre; DF, dietary fibre; DM, dry matter; GIT, gastrointestinal tract; L, linear; OH, oat hulls; Q, quadratic; SBP, sugar beet pulp; SI, small intestine.

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Table 1
Body weight of the broilers used for organ weights and digestive tract traits studies.

	Fibre inclusion (g/kg)	Body weight[a] (g)		
		6 d	12 d	18 d
Control	0	133	310	555
OH	25	129	315	565
OH	50	135	320	571
OH	75	127	295	553
SBP	25	130	318	577
SBP	50	131	309	569
SBP	75	127	297	538

[a] Average of two broilers per cage (6 replicate cages per treatment and age).

and compromise gastrointestinal tract (GIT) function and nutrient utilization (Jiménez-Moreno et al., 2011a, 2011b; Svihus, 2011).

Inclusion of whole grains and coarse grinding of ingredients are feeding practices often used to reduce feed cost and the incidence of digestive disturbances in broilers (Hetland et al., 2002; Svihus et al., 2004; Gabriel et al., 2008). Similar benefits to those observed with these practices have been reported when certain amounts of structural fibre such as oat hulls (OH), pea hulls or wood shavings were included in the diet (Hetland et al., 2003; Amerah et al., 2009; Jiménez-Moreno et al., 2011a). Fibre inclusion reduced gizzard pH (González-Alvarado et al., 2007; Jiménez-Moreno et al., 2009a), increased digestive juices secretion (Ikegami et al., 1990) and improved gizzard function and digesta flow, which might facilitate nutrient digestion and absorption (González-Alvarado et al., 2010; Svihus, 2011; Mateos et al., 2012).

Solubility, water holding capacity, viscosity, bulk, fermentative capability and other physico-chemical properties of fibrous ingredients affect the development and epithelial morphology of the GIT and consequently, they may have nutritional implications in poultry (Montagne et al., 2003; Jiménez-Moreno et al., 2009b, 2009c). In this respect, soluble fibrous fractions such as pectins from sugar beet pulp (SBP), are dispersible in water and might increase viscosity and bulk of the digesta (Bach Knudsen, 2001) delaying gizzard emptying. Also, an increase in digesta viscosity may reduce the rate of diffusion of digestive enzymes into the digesta, hampering nutrient absorption (Forman and Schneeman, 1980; Iji et al., 2001). On the other hand, insoluble fibrous fractions, such as those present in OH, stimulate gizzard activity and favour gastrointestinal refluxes which may improve nutrient digestibility (Hetland and Svihus, 2001; Hetland et al., 2003; Jiménez-Moreno et al., 2010). The hypothesis of this research was that the inclusion of moderate amounts of fibre into low fibre diets may have positive effects on the morphology, physiology and function of the GIT in young broilers, but that an excess could have opposite effects. The aim of this study was to evaluate the effect of increasing levels of two fibre sources (OH or SBP) with different physico-chemical properties on digestive characteristics and mucosa morphology of broilers from 1 to 18 d of age.

2. Material and methods

2.1. Fibre sources and diets

Chemical composition of the fibre sources and diets as well as the analytical procedures used, are reported in the companion paper (Jiménez-Moreno et al., 2013). Briefly, a batch of OH and a batch of SBP were ground using a hammer mill fitted with a 2-mm screen. The basal diet contained 580 g rice, 238 g soy protein concentrate, 76 g fish meal and 48 g soy oil/kg and had 13.6 MJ and 16 g CF (equivalent to 69 g dietary fibre; DF) per kg. The other experimental diets were prepared diluting (weight/weight) the control diet with 25, 50 or 75 g of either OH or SBP/kg. All diets were fed in mash form and met or exceeded the nutritional requirements of broilers as recommended by the Fundación Española Desarrollo Nutrición Animal (2008).

2.2. Husbandry and experimental design

Details on the husbandry and care of the chicks have been reported elsewhere (Jiménez-Moreno et al., 2013). Briefly, 504 one day (d)-old Ross 308 female chicks with an initial body weight (BW) of 47.8 ± 3.3 g were divided into 6 blocks by weight and the diets were randomly assigned to cages within each block. The trial was conducted as a completely randomized block design with seven treatments consisting in a negative control diet with a low fibre content (16 g CF/kg) and six additional diets arranged factorially with two sources of fibre (OH and SBP) and three levels of fibre inclusion (25, 50 and 75 g/kg).

2.3. Measurements of the GIT

At d 6, 12 and 18, two chicks per cage were randomly selected, weighed individually (Table 1) and euthanized by asphyxiation with CO_2. The digestive tracts with contents (from the end of the crop to the cloaca) were removed aseptically and weighed. Then, the liver, pancreas, proventriculus, gizzard, small intestine (SI, duodenum + jejunum + ileum) and ceca were excised, cleaned of digesta, dried with desiccant paper and weighed. Prior to digesta emptying, the proventriculus, gizzard