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Effects of the dietary level and source of sodium on growth performance, gastrointestinal digestion and meat characteristics in turkeys

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ABSTRACT

The aim of this 18 wk study was to evaluate whether a substantial decrease in dietary Na content and the use of Na sources alternative to NaCl might affect the growth performance, gastrointestinal digestion processes, carcass and breast meat traits of male turkeys. A total of 630 one-day-old heavy-type Large White BIG-6 male turkeys were assigned to nine dietary treatments according to a 3 × 3 factorial completely randomized design. The experimental factors included increasing supplementation levels of Na (0.8, 1.3, 1.8 g/kg) added to a basal diet containing 0.15–0.24 g Na/kg, and different Na sources (NaCl, $NaHCO_3$, Na_2SO_4). Regarding the gastrointestinal, carcass and meat parameters only two levels of Na supplementation (0.8, 1.8 g/kg) were evaluated. Increasing Na supplementation increased the growth rate of birds during wk 0–12 of the experiment, and the feed conversion ratio in particular over the first 4 wk ($P<0.05$, 0.8 *vs.* 1.3 and 1.8 g/kg). Sodium sources affected ($P<0.05$) feed conversion in particular during wk 9–12 of feeding, which was reflected in a decreased feed conversion rate in the $NaHCO_3$ and Na_2SO_4 treatments, compared with the NaCl treatment. The foot pad dermatitis score was not affected ($P>0.05$) by Na levels or sources. Sodium levels did not change ($P>0.05$) gastrointestinal parameters (i.e. pH, dry matter concentration), but they reduced ($P<0.05$, 0.8 *vs.* 1.8 g/kg) the serum concentrations of Mg, P, Na, and Cl. Sodium sources affected ($P<0.05$) gastrointestinal parameters. $NaHCO_3$ supplementation increased viscosity and dry matter concentrations in the small intestine, compared with the NaCl treatment, whereas Na_2SO_4 increased caecal dry matter concentrations. The activity levels of β-glucosidase and β-glucuronidase in the caeca were affected ($P<0.05$) by the Na source, caecal enzyme activities were increased by $NaHCO_3$, in comparison with NaCl and Na_2SO_4 supplementation. Short-chain fatty acid concentrations were not affected by Na levels or sources in the diet, except for acetate whose content increased with increasing Na levels (0.8 *vs.* 1.8 g/kg) and iso-butyrate which was affected ($P<0.05$) by Na source ($NaHCO_3$ *vs.* Na_2SO_4 and NaCl). Carcass and meat traits were partly affected ($P<0.05$)

Abbreviations: a^*, redness; b^*, yellowness; BW, body weight; BWG, body weight gain; Ca, calcium; Cl, chloride; D, dosage effect; DEB, dietary electrolyte balance; DM, dry matter; FCR, feed conversion ratio; FPD, foot pad dermatitis; H_2SO_4, sulphuric acid; K, potassium; L^*, lightness; Mg, magnesium; Na, sodium; NaCl, sodium chloride; $NaHCO_3$, sodium bicarbonate; Na_2SO_4, sodium sulphate; P, phosphorus; PSE, pale soft exudative meat; S, salt effect; SD, standard deviation; SCFA, short-chain fatty acid; SEM, standard error of the mean.

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by Na source, NaCl supplementation increased breast yield in comparison with $NaHCO_3$, and it decreased L^* values, compared with $NaHCO_3$ and Na_2SO_4 supplementation. Our findings show that a Na deficiency in the diet (0.8 g/kg) decreases the growth rate of turkeys and reduces the efficiency of feed utilisation. Sodium sources alternative to NaCl improve feed utilisation, but they may adversely affect breast muscle traits.

1. Introduction

The negative consequences of an increased dietary intake of Na include higher water consumption levels and a higher moisture content of litter (Mushtaq et al., 2007) which may increase the risk of many diseases and other health problems encountered in poultry production (Francesch and Brufau, 2004). A review of the recent literature shows that studies addressing the above issues have been conducted primarily on broiler chickens, while the number of experiments involving turkeys remains low. Thus, extensive research on the latter species has been postulated (Jankowski et al., 2011a). According to the National Research Council (1994), the minimum Na, K and Cl requirements of growing turkeys are 1.7, 7.0 and 1.5 g/kg diet, respectively, corresponding to a dietary electrolyte balance (DEB) of 211 mEq/kg. A linear relationship between Na consumption and the moisture content of excreta was observed in broilers fed diets characterised by a wide range (207–300 mEq/kg) of DEB values (Borges et al., 2003; Mushtaq et al., 2007). Therefore, a dietary application of NaCl, a common salt used as a feed ingredient, is an important consideration due to the reported increased excreta moisture associated with an elevated dietary Na and Cl content (Jankowski et al., 2011b). An adequate Na intake seems to be essential in numerous physiological processes, it affects enzyme activity and tissue protein synthesis (Olanrewaju et al., 2007). Some authors reported a beneficial influence of an increased dietary Na level on feed consumption, and thus the growth rate of broilers (Watkins et al., 2005; Mushtaq et al., 2007). Other researchers recommended a lower NaCl dosage (GfE, 1999) for broilers linking a higher moisture content of litter with an increased risk of many diseases, including foot pad dermatitis (FPD). Therefore, efforts have been made to use other sources of Na in poultry nutrition (Mushtaq et al., 2007; Jankowski et al., 2011b). Recent work on broilers revealed that Na_2SO_4, compared with $NaHCO_3$, seems to be a better alternative to dietary NaCl–especially during the starter period, as manifested by better feed utilisation, lower excreta moisture, and a lower FPD score (Jankowski et al., 2011b). On the other hand, very little information is available on the usefulness of NaCl alternatives in turkey nutrition, thus these issues should be more thoroughly investigated. In view of the above dietary concerns, this study was undertaken to evaluate the effect of different dietary Na levels (0.8, 1.3, 1.8 g/kg) and Na sources (NaCl, $NaHCO_3$, Na_2SO_4) on growth performance, feed conversion, small intestinal parameters (pH, viscosity, dry matter concentration), caecal fermentation processes (bulk effect, pH, microbial enzyme activity, short-chain fatty acid production), and breast meat quality characteristics (pH, colour indices) in turkeys.

2. Materials and methods

2.1. Animal protocol and dietary treatments

The animal protocol used in this study was approved by the Local Institutional Animal Care and Use Committee, and the study was carried out in accordance with EU Directive 2010/63/EU for animal experiments (OJEU, 2010). An 18 wk experiment was conducted at the Research Laboratory of the Department of Poultry Science, University of Warmia and Mazury in Olsztyn. A total of 630 one-day-old heavy-type Large White BIG-6 male turkeys, sexed at a local commercial hatchery (Ketrzyn, Poland), were randomly assigned to nine groups comprised of seven replicates, each of ten birds. The turkeys were kept in pens (4 m^2 each) on litter (wood shavings) in a building with a strictly controlled environment. Light was provided for 16 h per d. Indoor temperature was 32 °C at the beginning of the experiment and 16 °C at the end of wk 18. The birds had free access to feed and water. A 3 × 3 factorial design of 9 dietary treatments was used to evaluate the effects of graded levels of dietary Na (0.8, 1.3 and 1.8 g/kg) and different Na sources (NaCl, $NaHCO_3$ and Na_2SO_4). The composition of the basal diet is given in Table 1. The dietary Na levels were accomplished with the use of different premixes containing one of Na sources (Table 2). The premix, different for each diet, was mixed with the basal diet (1:99 w/w). Diets were assayed for the content of Na and K using flame atomic absorption spectroscopy. Dietary Cl content was determined by the biamperometric technique. The DEB was calculated using the formula: DEB mEq/kg = Na mEq/kg + K mEq/kg − Cl mEq/kg (Mongin, 1981). The carcass dressing percentage was calculated after 24 h chilling using the following formula: carcass weight including neck, relative to live body weight (in g/kg).

2.2. Measurements

At the end of each feeding period, on d 28, 56, 84, and 126 of the experiment, the birds were weighed, and feed intake was recorded. Body weight gain (BWG) and feed conversion ratio (FCR) were calculated for each period. The excreta dry matter (DM) was estimated on d 49 and 112. Mortality rates were recorded daily, and the weights of dead birds were used to adjust average daily gain, average daily feed intake, and FCR. For performance indices, each replicate ($n = 7$) was considered as the