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Growth, water intake, litter moisture, carcass and physiological traits of broiler chickens fed varying levels and sources of potassium under phase feeding system

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ABSTRACT

The concept of dietary electrolyte balance (DEB) was evaluated using 1-d-old straight-run Hubbard broiler chicks (total, 1472) and 4 dietary K (dK) levels (0.86%, 1.02%, 1.18%, and 1.34%) and 2 sources of dK salt (K_2CO_3 and K_2SO_4) in a 4×2 factorial arrangement of treatments. The 4 dK levels corresponded to DEB values of 200, 240, 280, and 320 mEq/kg, respectively. Each of the 8 dietary treatments was randomly allocated to 4 replicates with 46 birds per replicate. The experimental diets were prepared separately for each phase, i.e., prestarter (d 1–10), starter (d 11–20), grower (d 21–33), and finisher (d 34–42). Analyzed water characteristics (pH, temperature, salinity, dissolved oxygen, electrical conductivity, and total dissolved solids) and electrolytes were found within the recommended range. Feed intake ($P=0.05$), daily water intake ($P=0.04$), and mortality ($P=0.02$) were increased by replacing K_2CO_3 with K_2SO_4. The source and level interaction was found to affect litter moisture ($P=0.04$). Either varying levels or replacing salts of dK did not result in improved growth performance that was mainly associated with the simultaneously reduced capacity of the digestive (gizzard and proventriculus) and lymphoid (bursa and spleen) organs of the body. The dK and changing salt (K_2CO_3 with K_2SO_4) resulted in a greater dressing percentage ($P=0.008$), abdominal fat ($P=0.03$), and blood pH ($P=0.01$) but did not affect body, breast, and thigh weights. Increasing serum K, Na, and HCO_3 were compensated with reduced serum Ca and Cl in higher dK diets. It is inferred that lower levels of dK (i.e., 0.86%) could be used to enhance broiler growth. The supplementation of K_2SO_4 improved feed and water intake, but reduced livability. The increasing supplementation of dietary K from K_2SO_4 improved carcass responses and reduced the digestive and lymphoid organ capacity.

1. Introduction

Potassium is abundantly found in animal body especially in muscles and nerve cells (Leeson and Summers, 2001). The diets rich in K favourably affect acid–base balance owing to the precursors of bicarbonate, which

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neutralized acidogenic conditions in the biological fluids (Sebastian et al., 1994). Dietary K (dK) has been studied extensively together with other electrolytes (Na and Cl), amino acids (Lys, Met, and Arg) and energy (Reece et al., 1984; Ribeiro et al., 2008; Roussan et al., 2008; Stutz et al., 1971). The dK along with other strong ions (i.e., Na and Cl) was reported to influence vital body regulatory functions, including maintenance of tissue fluids, acid–base balance, osmoregulation, and nerve transmission (Hooge, 2003). The dietary addition of strong cations (Na and K) has been used to compensate depressed growth in chickens caused by high levels of strong anion (Cl) and vice versa (Ahmad et al., 2005, 2008; Mushtaq et al., 2005, 2007). However, it is well established (Ahmad et al., 2005, 2008; Borges et al., 2003; Murakami et al., 2001; Rondon et al., 2001) that the responses of dK are not independent but dependent, more specifically, on dietary electrolyte balance (DEB; Na+K–Cl, mEq/kg).

There are well documented reports on the subject of strong ions and DEB, which indicated that manipulating any of the strong ion (Na, K or Cl), in fact, changed the DEB, which in turn affected the performance of the birds. The DEB range between 150 and 350 mEq/kg is quite wide and most of the researchers agreed on an optimal DEB value of 250 mEq/kg (Hooge, 2003; Mushtaq et al., 2005, 2007). However, different ions acted differently on a similar DEB of 250 mEq/kg (Mushtaq et al., 2005, 2007). This vast variation in DEB recommendations might be associated with the fact that most of the previous studies were conducted with a special relation to heat stress in broiler chickens. The addition of K salts reduced the severity of heat stress, which was reflected in the improved growth performance in broiler chickens kept under high temperature (Teeter and Smith, 1986). Potassium carbonate is considered as a potential source of dK (Hooge, 2003), while K_2SO_4 has been shown to reduce litter moisture in broiler chickens (Hooge et al., 1999).

The modern poultry production is shifting towards controlled housing systems and improved genetics, therefore, the nutrient requirements of today's broiler chickens are changing on a daily basis. Hence, there is a need to reconsider the requirement of dK and DEB and furthermore to evaluate the best K salt for broilers fed under the phase feeding system. The present study was, therefore, conducted to evaluate the effect of supplementation of dK with the concept of the DEB using different salts on growth performance, water intake, litter moisture, carcass and body organ responses, and serum mineral chemistry of the modern broiler strain fed under the phase feeding program.

2. Materials and methods

All the experimental procedure was approved by Advanced Study and Research Board, University of Veterinary and Animal Sciences, Lahore, Pakistan.

2.1. Housing and management

A total of 1472 (42.9 ± 1.2 g) 1-d-old straight-run Hubbard broiler chicks (Hubbard × Hubbard) were randomly allocated to 8 dietary treatments with 4 replicate pens per diet and 46 broiler chicks per pen. A floor space of 0.09 m^2 was provided for each bird. One flat bottom round feeder was provided for each experimental pen. Birds were housed in an environment control system. Minimum and maximum temperature and relative humidity were recorded and maintained according to the Hubbard production manual. Light was provided 24 h for the first 3 d, and, thereafter, a light pattern of 23 h light:1 h dark was adopted for the entire experimental period. 7.5 cm deep fresh sawdust was used as litter material over a concrete floor. Birds were vaccinated against Newcastle Disease plus Infectious Bronchitis viruses at d 4, Infectious Bursal Disease virus at d 8 and again at d 14; Hydropericardium Syndrome virus at d 18, and Newcastle Disease-Lasota strain at d 22 according to the local recommended schedule.

2.2. Dietary treatment

A basal diet was formulated to contain 0.70% dK, 0.15% Na, and 0.30% Cl, with a DEB value of 160 mEq/kg. Four levels of dK (i.e., 0.86%, 1.02%, 1.18%, and 1.34%) were supplemented to the basal mash diet with either feed-grade K_2CO_3 or K_2SO_4, which corresponded to DEB values of 200, 240, 280, and 320 mEq/kg, respectively (Table 1). The experimental period was divided into 4 phases, i.e., pre-starter (d 0–10), starter (d 10–20), grower (d 20–33), and finisher (d 33–42), which met or exceeded the nutrient specifications recommended by the management guide (Hubbard, 2004).

2.3. Dietary analyses

Analyzed proximate composition (AOAC, 2005) values of ingredients were used in the feed formulation. The Na and K contents of each ingredient were analyzed by flame photometer (AOAC, 2005) and Cl by titration with $AgNO_3$ (Lacroix et al., 1970). The Na, K, and Cl contents of the final diets were again verified prior to start of the experiment. Metabolizable energy of each ingredient was calculated by using appropriate regression equations as suggested by NRC (1994). Amino acids, based on dry matter and CP contents of each ingredient, were calculated (AminoDat 3.0 Platinum; Degussa AG, Essen, Germany). The amino acid composition of each diet was either met or exceeded the ideal amino acid ratio as suggested by Han and Baker (1994). The experiment lasted for 42 d of age and the diets were offered *ad libitum* throughout the experimental period.

2.4. Water supply, analysis, and consumption

Each replicate pen was equipped with separate overhead, transparent and volume-graduated 20 L water bottles linked to nipple drinker line. Water characteristics were recorded twice (morning and noon) daily for its pH by pH metre (LT-Lutron pH-207; Lutron Electronic Enterprise Co., Ltd., Taipei, Taiwan), dissolved oxygen (DO) by DO metre (YSI 55 Incorporated, Yellow Springs, OH, USA), temperature, electrical conductivity (EC), total dissolved solids (TDS), and salinity by Combo metre (H M Digital Inc., CA, USA). These observations were recorded randomly from different replicates (Table 2). Water intake (DWI) was recorded on a