Influence of graded levels of dietary sodium on the development of footpad dermatitis in broiler chickens

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Primary Audience: Broiler Producers, Service Personnel, Production Managers

SUMMARY

An experiment was conducted to investigate the effects of graded levels of dietary Na (0.15, 0.20, 0.25, and 0.30% Na) on the live performance and development of footpad dermatitis (FPD) in broiler chickens reared to 49 d of age. On the day of hatch, 1,280 mixed-sex chicks were randomly allotted to 4 treatments, with 8 replicate pens of 40 broilers per pen. Feed and water consumption were monitored and litter samples were analyzed for moisture. The incidence and severity of FPD were assessed by examining all birds on d 28 and 49. Dietary supplementation of broiler diets with graded levels of Na improved \((P < 0.05)\) FCR on d 14 (linear and quadratic), BW on d 28 and 49 (linear), decreased mortality on d 49 (linear), and increased total water consumption (linear). Litter moisture level also increased \((P < 0.001)\) linearly from 24% (0.15% Na) to 32% (0.30% Na) on d 49. Moreover, the incidence and severity of FPD on d 28 and 49 were increased linearly with Na levels in the diet. On d 49, FPD severity was the most severe for broilers receiving the highest dietary levels of Na. With these results, we confirm earlier reports that high dietary Na can increase litter moisture and can therefore be a direct trigger of FPD development in broiler chickens.

Key words: broiler, footpad dermatitis, performance, sodium

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DESCRIPTON OF PROBLEM

Sodium is an essential nutrient known to influence several aspects of normal animal growth. The optimal dietary balance of Na and Cl allows efficient growth performance [1]. The dietary Na level directly influences water consumption [2, 3], the acid-base balance [4], and basal metabolism [5, 6] in poultry. It has been suggested that dietary electrolyte balance is a principal factor in acid-base balance regulation, which determines blood pH for better enzymatic efficiency and thus influences bird growth and performance [7, 8]. A wide range of requirements for both Na and Cl have been reported. Murakami et al. [9] suggested that a Na level of 0.15% was sufficient to maintain maximum BW, FCR, and tibia ash of male broilers grown to 56 d. Oviedo-Rondón et al. [10] reported that the Na and Cl requirements for optimal perfor-

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mance of young broiler chickens were 0.28 and 0.25%, respectively. Mushtaq et al. [11] con-
cluded that the dietary requirements for growing broilers were 0.20 to 0.25% Na and 0.30% Cl
from 29 to 42 d of age at ambient temperatures ranging from 32 to 40°C. The NRC increased
the minimum recommended level of Na and Cl in diets for broilers 0 to 21 d from 0.15% [12] to
0.20% [13].

The control of excreta or litter moisture is a
priority in the modern poultry industry to avoid
flock health, environment, and animal welfare
problems and to reduce productivity losses. The
influence of dietary Na level on water intake and
litter moisture is well documented [10, 11, 14–
18], and there is wide agreement among authors
that an excess of Na in chicken diets increases
litter moisture. The current study was conducted
to reevaluate the influence of graded levels of
dietary Na on litter moisture and the develop-
ment of footpad dermatitis (FPD) in broiler
chickens reared to 49 d of age.

MATERIALS AND METHODS

A total of 1,280 mixed-sex Ross 708 [19]
broiler chicks were randomly divided into 4
treatments (0.15, 0.20, 0.25, and 0.30% Na) with
8 replicate pens of 40 broilers per pen, achieving
a stocking density of 29 kg/m² from 0 to 49 d
(11 birds/m²). Broilers were reared in an open-
sided, temperature- and ventilation-controlled
(with exhaust fans), concrete-floor house con-
taining fresh pine shavings (total bedding 8 cm
depth) as a bedding material. Water was obtained
from the municipal water source and was grav-
ity-fed from 15-L containers to the nipple line
in each pen. Each pen was also supplied with
hanging feeders to provide ad libitum access to
feeds (starter, grower, and finisher), and light-
ing was provided on a 23L:1D schedule. Dietary
treatments consisted of 4 diets fed in crumbled
form through 14 d of age and pelleted thereaft-
er. Dietary treatments were formulated with the
same energy and nutrient concentrations, with
0.15, 0.20, 0.25, and 0.30% Na and 0.23, 0.30,
0.38, and 0.46% Cl across the starter, grower,
and finisher phases. With the exception of Na,
all other nutrient requirements [20] were met by
the basal diet for 0- to 49-d-old broilers. The nu-
trient composition of the basal diet is presented
in Table 1.

The research trial was conducted with the
written approval of the Auburn University Ani-
mal Care and Use Committee. Average BW (by
pen), feed consumption (FC), FCR, and percent-
age mortality were determined at 14, 28, and
49 d of age, whereas water consumption (WC;
WC:BW, WC:FC) was calculated at the end of
the study. Mortality was recorded twice daily
and weighed to calculate the adjusted FCR. Lit-
ter samples (per-pen basis) were collected at the
beginning and end of the experiment. Collection
was performed by using an empty 200-mL

Table 1. Nutrient composition of the basal diet

<table>
<thead>
<tr>
<th>Item</th>
<th>Feeding stage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Starter</td>
</tr>
<tr>
<td><strong>Ingredient, %</strong></td>
<td></td>
</tr>
<tr>
<td>Corn</td>
<td>55.87</td>
</tr>
<tr>
<td>Soybean meal (48% CP)</td>
<td>33.73</td>
</tr>
<tr>
<td>Poultry by-product meal</td>
<td>4.0</td>
</tr>
<tr>
<td>Poultry fat</td>
<td>2.4</td>
</tr>
<tr>
<td>Defluorinated phosphate</td>
<td>1.35</td>
</tr>
<tr>
<td>Ground limestone</td>
<td>1.13</td>
</tr>
<tr>
<td>NaCl</td>
<td>0.4</td>
</tr>
<tr>
<td>Vitamin premix²</td>
<td>0.5</td>
</tr>
<tr>
<td>Trace mineral premix³</td>
<td>0.25</td>
</tr>
<tr>
<td>ß-Met</td>
<td>0.3</td>
</tr>
<tr>
<td>L-Lys</td>
<td>0.02</td>
</tr>
<tr>
<td>Coccidiostat⁴</td>
<td>0.05</td>
</tr>
<tr>
<td><strong>Calculated composition, %</strong></td>
<td></td>
</tr>
<tr>
<td>CP</td>
<td>23.6</td>
</tr>
<tr>
<td>ME, kcal/kg</td>
<td>3,100</td>
</tr>
<tr>
<td>Ca</td>
<td>0.93</td>
</tr>
<tr>
<td>Available P</td>
<td>0.45</td>
</tr>
<tr>
<td>Lys⁵</td>
<td>1.3</td>
</tr>
<tr>
<td>Met + cystine⁵</td>
<td>1.0</td>
</tr>
<tr>
<td>Na</td>
<td>0.15</td>
</tr>
<tr>
<td>Cl</td>
<td>0.23</td>
</tr>
</tbody>
</table>

1Starter diet fed at 680 g/bird, grower diet fed at 3,171 g/
bird, and finisher diet fed at 2,265 g/bird or until the end of
the trial.

²Vitamin premix supplied the following per kilogram of
diet: retinol acetate, 1,706 mg; cholecalciferol, 41 mg; dl-α-
tocopherol, 27 mg; menadione, 0.99 mg; cobalamin, 0.015
mg; folic acid, 0.8 mg; pantothenic acid, 15 mg; ribofla-
vin, 5.4 mg; niacin, 45 mg; thiamine, 2.7 mg; d-biotin, 0.07
mg; pyridoxine, 5.3 mg.

³Supplied the following per kilogram of diet: Mn, 90 mg;
Zn, 83 mg; Fe, 121 mg; Cu, 12 mg; I, 0.5 mg; Se, 0.3 mg.

⁴Monensin Na premix, Coban 90 (Elanco Animal Health,
Indianapolis, IN).

⁵Amino acids in the diets are shown in total levels.
Table 2. Effect of graded levels of dietary Na on the live performance of broiler chickens\(^1\)

<table>
<thead>
<tr>
<th>Item</th>
<th>d 1 to 14</th>
<th>d 1 to 28</th>
<th>d 1 to 49</th>
<th>WC:BW, L/kg</th>
<th>WC:FC, L/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BW, g</td>
<td>FCR, g</td>
<td>WC:BW, L/kg</td>
<td>Mortality, %</td>
<td>BW, g</td>
</tr>
<tr>
<td>Dietary Na, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.15 (control)</td>
<td>335(^b)</td>
<td>1.17(^a)</td>
<td>390</td>
<td>0.75</td>
<td>1,240</td>
</tr>
<tr>
<td>0.20</td>
<td>355(^a)</td>
<td>1.13(^b)</td>
<td>401</td>
<td>0.63</td>
<td>1,280</td>
</tr>
<tr>
<td>0.25</td>
<td>358(^a)</td>
<td>1.11(^b)</td>
<td>396</td>
<td>0.38</td>
<td>1,281</td>
</tr>
<tr>
<td>0.30</td>
<td>353(^b)</td>
<td>1.13(^b)</td>
<td>397</td>
<td>0.63</td>
<td>1,289</td>
</tr>
<tr>
<td>SEM(^2)</td>
<td>5.11</td>
<td>0.008</td>
<td>5.34</td>
<td>0.35</td>
<td>15.3</td>
</tr>
<tr>
<td>(P &lt; F)</td>
<td>*</td>
<td>***</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

\(P\)-value, orthogonal polynomial contrast

- Linear: * *** NS NS * NS * NS NS NS NS NS NS NS NS NS
- Quadratic: * *** NS NS * NS * NS NS NS NS NS NS NS NS NS
- Cubic: NS NS NS NS NS NS NS NS NS NS NS NS NS NS NS

\(^{a,b}\)Means within a treatment and column with different superscripts differ significantly \((P < 0.05)\).

\(^1\)FCR is adjusted for mortality. FC = feed consumption; WC:BW = water consumption/pen weight (L/kg); WC:FC = water consumption/ feed consumption (L/kg).

\(^2\)Pooled SEM.

\(* P < 0.05; ** P < 0.01; *** P < 0.001; NS at P > 0.05.\)
beaker and consisted of a 10-cm core sample of litter taken from 3 different areas (i.e., under the nipple drinkers, on the side of the feeders, and in the middle of the pen) in each pen as described by Macklin et al. [21]. The footpads of all birds were scored for the presence of gross FPD lesions at 28 and 49 d of age. A 3-point scoring system was used, in which 0 = no lesions, 1 = mild lesions, and 2 = severe lesions, as described by Bilgili et al. [22]. Data were subjected to ANOVA in a completely randomized design, using the GLM procedure of SAS [23]. Data analysis was conducted following arcsine transformation. Orthogonal polynomial contrasts were calculated to assess the response to graded levels of dietary Na.

RESULTS AND DISCUSSION

Live performance results (BW, FC, FCR, mortality, WC:BW ratio, and WC:FC ratio) at 14, 28, and 49 d of age are presented in Table 2. Increasing dietary Na improved ($P < 0.05$) FCR on d 14 (linear and quadratic), linearly ($P < 0.05$) increased BW on d 28 and 49, and linearly decreased mortality on d 49. In addition to this, the highest ($P < 0.05$) WC:FC ratio (L/kg of feed) was found in the treatment that received 0.25% of dietary Na. Sklan and Noy [24] reported that Na has a critical function in feed consumption just after hatching and also in the secretion and activity of digestive enzymes. Maiorka et al. [25] fed day-old broiler chicks experimental diets containing different levels of dietary Na from 1 to 7 d of age. These authors suggested optimal dietary Na levels of 0.45% for WC, 0.40% for FC and BW gain, and 0.38% for FCR. In addition, these authors concluded that neither Na level nor electrolyte balance influenced litter moisture until 7 d of age. Murakami et al. [26] stated that dietary levels of 0.15% of Na$^+$ and 0.23% of Cl$^-$ were adequate for maximum performance of growing chickens between 21 and 42 d of age. The results herein are consistent with those reported by Mushtaq et al. [11], who observed a linear effect of increasing dietary Na on BW gain. The increased BW and lower mortality observed in treatments with an increasing Na level could be attributed to additional WC that was stimulated by the dietary Na level. The present trial was conducted during periods of high summer temperatures (between 35 and 42°C in July and August). Deleterious effects of a high ambient temperature may be
minimized by the dietary manipulation of electrolyte salts and by maintaining sufficient water intake in heat-stressed birds because water acts as a heat sink during high temperatures.

The data for WC (L/pen), litter moisture, and FPD incidence and severity are presented in Table 3. Increasing the dietary Na level in a linear fashion \((P < 0.001)\) increased the litter moisture level from 24% (0.15% Na) to 32% (0.30% Na) on d 49 (Table 2). A linear increase \((P < 0.001)\) was also observed in WC because of increased dietary Na levels (Table 3). These observations are consistent with previous reports in the literature that correlated dietary Na level with litter moisture [10, 15, 16, 18, 27–29]. Birds fed the highest level of Na (0.30%) had a higher \((P < 0.001)\) incidence of FPD at d 49 and a higher \((P < 0.01)\) severity of FPD at d 28 compared with birds consuming 0.15% Na (Table 3). This effect was associated with, and contributed to, increased \((P < 0.001)\) levels of litter moisture in pens of birds fed high levels of Na. These data agree with those of Mayne et al. [14] and Cengiz et al. [30]. Footpad dermatitis has been observed to be more severe as litter moisture increases, especially when the litter contains sticky cecal droppings [31, 32]. Harms and Simpson [27] observed a significant effect of dietary NaCl level in poult diets on the severity of FPD lesions. It is clear from these results and previously published studies that increases of dietary Na levels \((P < 0.001)\) in litter moisture \((P < 0.001)\) in litter moisture at d 49.

### CONCLUSIONS AND APPLICATIONS

1. Broiler performance was significantly influenced in a positive manner in this study when dietary Na was increased from 0.15 to 0.25%.
2. Water consumption was increased in a linear fashion \((P < 0.001)\) with increasing dietary Na, and the increase in WC resulted in a progressive increase \((P < 0.001)\) in litter moisture at d 49.
3. Dietary Na levels above 0.25% increased the incidence of FPD in broiler chickens.

### REFERENCES AND NOTES

19. Aviagen, Huntsville, AL.


