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Comparison of Source and Levels of Sodium in Broilers under Low Temperature Conditions

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Abstract.- The objective of the present study was to evaluate the effect of two sources of sodium at different levels on broiler performance, water consumption and blood Na concentration under low temperature conditions. Six corn-soy based experimental diets containing graded levels (0.15, 0.20 or 0.25 %) of sodium either from sodium chloride or sodium bicarbonate were assigned to 240 day old Hubbard broilers. Higher level of sodium (0.25%) especially when the source was sodium chloride, resulted in an increase ($P<0.05$) in body weight and feed efficiency during first two weeks of age. However there was no carryover effect of this increase at the end of experiment. Feed consumption was independent of dietary Na treatments ($P>0.05$). Water consumption was increased ($P<0.05$) with the increasing level of Na in diet, but source of Na did not show any difference. Blood Na concentration showed a linear increase ($P<0.05$) from low to high level of Na. This increase was more pronounced when Na was added in diet as sodium bicarbonate. It can be concluded that feeding higher sodium levels especially as sodium chloride for first two weeks may result in increases in body weight and feed efficiency but this effect did not persist till marketable age of broiler. Water consumption and blood Na concentration has direct relationship with level of Na in diet.

Keywords: Sodium, low temperature, broiler.

INTRODUCTION

Countries like Pakistan which are located in the tropical area of the world face extreme of weathers *i.e.* high and low environmental temperature. The maximum high temperature touches the figure of 45°C and the lowest 1°C. These extremes of weather adversely affect the production performance of broilers. The problem becomes more pronounced, particularly, when the broiler chickens are in the growing and finishing phases of their life. Usually, it is observed that birds consume less water under low environmental temperature which results in decrease feed intake, body weight gain and livability and increasing the feed conversion ratio. This reduction of efficiency is partly explained by decreased metabolic utilization of nutrients and reduced protein retention. As water is an important nutrient which helps in the assimilation of feed, if consumed less may lead to poor digestion of feed. Borges *et al*. (2004) reported that ambient temperature and diet can influence the acid base balance in poultry. Moreover, the forages of tropical locations are often low in their Na content than the plants produced in the temperate zones of the world. So far as the animal class and physiology status is concerned the rapidly growing and high producing animals require more NaCl.

It may be assumed that whether it is hot or cold, under both condition birds can lose its sodium content of diet. Sodium (Na) is a least expensive nutrient and its dietary change does not bring any major effect on feed price. Insufficient Na lowers the utilization of digested protein and energy. Sodium requirement for growing chicken is 0.15% according to the recommendation of NRC (1994). However, Oviedo-Rondon *et al*. (2001) described it as 0.28% and according to Hubbard's specification the Na requirement is 0.18%.

Na requirement for the best chicken performance was estimated 0.20% of ration from 21 to 49 d of age (Zanardo, 1994) and 0.15% from 42 to 56 d of age (Murakami *et al*., 1997). The same authors reported no difference between $NaHCO_3$ and NaCl as Na sources. Whereas requirement of Na for maximum body weight gain (BWG) and for the best feed conversion ratio (FCR) was estimated

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0.25% and 0.29%, respectively (Barros *et al*., 1998).

As described by previous workers sodium is a mineral with important physiological functions. Optimum dietary balance of this mineral allows better chicken performance and may reduce leg problems. To determine nutritional requirements it is important to keep this balance. The NRC (1994) recommended a minimum requirement of 0.15% Na for young broiler chickens. Britton (1991, 1992) concluded that to obtain the best body weight gain (BWG) the NaCl level should be 0.45%, or Na at 0.20% of the diet and the Cl requirement should be about 0.20%. The NRC (1994) has established requirements of 0.20% each for Na and Cl for 0 to 3 wk old chicks. These levels have been confirmed by Zanardo (1994).

Sodium bicarbonate (SBC) has advantage over sodium chloride because it provides sodium, which favorably affects blood pH and supplies beneficial bicarbonate (Mongin, 1968). A survey of SBC use in broiler feeds in Western Europe reported that "0.2% was the most common level used, in conjunction with 0.1% added NaCl; and the main purpose was to lower dietary chloride and reduce wet litter problems (Merrill, 1993). Optimal levels of dietary SBC is reported to be 0.20 to 0.30% for broilers fed ionophores, grown on built-up litter, and given a coccidial inoculation, based on significant improvements in weights, feed efficiencies, coccidial lesion scores, mortalities, and carcass yields, compared to control results in several dose-response studies (Hooge *et al*., 1999)".

Majority of poultry farming in the country is still carried out in open houses. The broilers reared under these husbandry practices are directly encountering this harsh weather condition. The duration of this minimum temperature range starts from November to February. Keeping in view the status of open house farming in the country, the objectives of the present study was to investigate and elucidate possible effect of different levels of sodium from two different sources (NaCl and $NaHCO_3$) on the productive performance of broilers.

MATERIALS AND METHODS

The experiment was performed in the Department of Poultry Production, University of Veterinary and Animal Sciences Lahore, Pakistan during winter 2007. For this purpose 240 day old Hubbard straight run broilers chicks were procured, weighed in groups of ten, and randomly divided into six groups of 40 chicks each designated as A, B, C, D, E and F. Group A and D acted as control for NaCl and $NaHCO_3$, respectively. Each group was further divided into four replicates of 10 chicks each. In this way total 24 replicates were constituted. They were reared under standard husbandry condition. For the first fifteen days the house temperature was maintained in between 90-95°F Water and feed was provided *ad libitum*. The room temperature was noted three times a day *i.e*. at 8 a.m, 4 p.m and 00 hrs. On daily basis the mean room temperature of the day was recorded. At the end of experiment the mean temperature (70.6°F) of whole duration was recorded. Likewise the humidity was recorded twice a day *i.e*. at 8:00 AM and 8:00 PM and mean humidity (48.5%) was recorded at the end of experiment.

Table I.- Composition of experimental diets.

Diet	Level of sodium (%)	Source of sodium
A	0.15	Sodium chloride
B	0.20	Sodium chloride
C	0.25	Sodium chloride
D	0.15	Sodium bicarbonate
E	0.20	Sodium bicarbonate
F	0.25	Sodium bicarbonate

Diets

Six corn-soy based experimental diets containing graded levels (0.15, 0.20 or 0.25 %) of sodium either from sodium chloride or sodium bicarbonate were formulated (Table I). Each of these treatments was assigned to 4 replicate pens of 10 broiler chicks (40 birds / treatment). Daily water consumption was measured. Body weight and feed consumption were recorded weekly and used to calculate feed efficiency.

Feed consumption

In the beginning the starter ration offered to group B and C was mixed with 7 and 12 grams of

NaCl in the bag of 50 kg to bring the level of sodium 0.20 and 0.25%, respectively. Similarly the rations offered to groups E and F were mixed with 7 and 12 grams of $NaHCO_3$ to bring the level of sodium at 0.20 and 0.25%, respectively. The rations offered to control groups *i.e.,* A and D contained 0.15% of sodium as prescribed by NRC (1994). These rations were offered to the birds from day one to the end of fourth week. In the last two week finisher ration was mixed in the same way as in starter ration. At the end of each week the data regarding feed consumption, weight gain and consequently feed efficiency was recorded.

Water consumption

The water was offered to all birds in the plastic graduated waterers having capacity of five liters. Each pen of ten chicks had a separate waterer. The water was offered at 8:00 AM and next day at the same time the left over water was measured and recorded for each replicate. This practice continued till the end of experiment.

Blood collection

At the end of experiment two birds from each replicate were selected randomly and slaughtered for blood collection. The blood was collected, approximately 10 ml. in sterilized test tube containing an anticoagulant (Heparin). These test tubes were put in the refrigerator for further analysis

Statistical analysis

The data thus obtained were analyzed by variance analysis using the procedure described by Steel *et al*. (1997). Mean values were considered significant at $p \leq 0.05$. In case of significant differences Duncan multiple range test was applied to compare differences among means obtained during different treatments (Duncan, 1955).

RESULTS AND DISCUSSION

Temperature and humidity

In the present experiment the minimum (61.4°F) and maximum (79.8°F) average room temperature from first to sixth week of broiler age showed low temperature conditions. The average percent RH was 48.5 (minimum 40, maximum 57).

Bird performance

Results on production performance are divided into three phases; first phase comprises of day old to 14th day of age; second phase ranges from 15th to 28th and third phase 29th to 42nd day of age. Data on weight gain, feed intake and feed efficiency are presented in Table II.

Table II.- Effect of different sources and levels of sodium on weight gain, feed intake and feed efficiency of broilers reared under low temperature from 1-42 days.

Treatment[1]	1-14 days	15-28 days	29-42 days	Total
Weight gain (g)				
A	301[c]	523	902	1526
B	305[c]	529	912	1546
C	320[a]	523	913	1565
D	309[b]	518	896	1523
E	299[cd]	516	915	1530
F	311[b]	527	911	1549
Pooled SEM[2]	11.2	9.8	12.7	18.5
Feed intake (g)				
A	487	877	1528	2892
B	501	868	1539	2908
C	513	896	1557	2966
D	498	839	1509	2846
E	492	847	1541	2880
F	508	858	1529	2895
Pooled SEM[2]	15.2	22.6	16.7	28.5
Feed efficiency				
A	1.62[bc]	1.68	2.18	1.90
B	1.64[a]	1.64	2.16	1.88
C	1.56	1.71	2.18	1.90
D	1.61[c]	1.62	2.17	1.87
E	1.65[a]	1.64	2.16	1.88
F	1.63[abc]	1.63	2.15	1.87
Pooled SEM[2]	0.013	0.009	0.006	0.003

[1]A, B, and C represents dietary sodium level 0.15, 0.20 and 0.25 % respectively with sodium chloride as source; D, E and F represents dietary sodium level 0.15, 0.20 and 0.25 % respectively with sodium bicarbonate as source.
[2]Pooled standard error of means
[a-d]Means in a column and with no common letters differ significantly ($P < 0.05$)

Weight gain

During first phase highest weight gain was observed in birds fed diet C containing sodium @

0.25 from sodium chloride as source while lowest weight was obtained on diet E which had 0.20 % sodium from SBC. Significant ($P<0.05$) differences were observed for data on weight gain during first phase of production. The performance results for weight gain during 15th day to 28th showed non significant ($P>0.05$) results however maximum weight gain was noticed in diet B and minimum on diet E. Same trend was continued during the third and last phase of production where no significant difference was found among different treatment with highest on diet E and lowest on diet D.

Higher level of sodium (0.25%) especially when the source was sodium chloride, resulted in an increase ($P<0.05$) in body weight during first two weeks of age. However, there was no carryover effect of this increase at the end of experiment. Barros *et al*. (1998) in their study reported that maximum body weight gain could be achieved on when sodium is added at 0.25%. These results are in line with the earlier report of Zanardo (1994). Murakami *et al*. (1997) also documented no difference between sodium bicarbonate and sodium chloride as sodium sources.

Feed intake

Data on feed intake is given in the Table III. In the first phase of production (1-14 days) maximum feed intake was observed in birds fed diet F containing sodium @ 0.25 from SBC as source while lowest weight was obtained on diet A which had 0.15 % sodium from sodium chloride. However, no significant differences ($P>0.05$) was observed. During the second phase of production among different treatment highest feed intake was noticed on diet A and lowest on diet D. The performance results for feed consumption during 29th day to 42nd day found maximum feed taken by the birds fed on diet C and minimum on diet D. When feed intake was summed up for the total duration it was found that diet C was the diet on which birds consumed maximum feed whereas diet D was ranked lowest with respect to feed consumption. However, feed consumption was independent of dietary sodium treatments ($P>0.05$).

In agreement with the findings of Murakami *et al*. (1997) source or level of sodium has no impact on the feed consumption of broilers.

Feed efficiency

Feed efficiency was calculated using the data on weight gain and feed intake. Results for feed efficiency after statistical analysis are presented in Table II. It has been observed that feed efficiency significantly differ ($P<0.05$) during starter phase (1-14 days). Best efficiency in this phase was on diet C containing sodium @ 0.25 from sodium chloride as source while lowest efficiency was obtained on diet E which had 0.20% sodium from sodium bicarbonate.

Same trend was observed for weight gain of the birds which did not persist during the latter stages. In the phase 2 (15-28 days) non significant ($P>0.05$) differences were observed, however maximum feed efficiency was noticed in diet D and minimum on diet C. Same trend was continued during the third and last phase of production where no significant difference was found among different treatment with better feed efficiency on diet F and lowest on diet C. When we compared overall (1-42 days) feed efficiency values it was revealed that diet D was best and diet C was least efficient in converting feed into gain.

Water parameters

Data on water intake, water: feed and litter moisture as affected by various levels and sources of sodium are presented in Table III. The water intake was increased significantly *(*$P<0.05$) among the treatments. Maximum water intake was observed in group fed with diet C and minimum on diet A. However, the ratio between water and feed showed somewhat different trend as maximum water: feed was noticed on diet F and minimum on diet A. In this way water data demonstrate that control diet having 0.15% sodium in the form of sodium chloride has minimum water consumption as well as water to feed ratio and with increasing level of sodium water intake significantly ($P<0.05$) increased. This increase was more pronounced when sodium chloride was used as a source as compared to sodium bicarbonate. High litter moisture contents ($P<0.05$) were determined in groups having high level of sodium. However source of sodium has no effect.

Table III.- Effect of different sources and levels of sodium on water parameters of broilers reared under low temperature from 1-42 days.

Treatment[1]	Water intake (ml per bird)	Water: feed (ml/g)	Litter moisture (%)
A	5172^{cd}	1.793^{d}	33.48^{d}
B	5226^{b}	1.802^{b}	37.04^{b}
C	5297^{a}	1.795^{d}	37.98^{a}
D	5202^{bc}	1.831^{ab}	32.15^{d}
E	5248^{b}	1.822^{bc}	36.11^{bc}
F	5288^{a}	1.837^{a}	37.35^{ab}
Pooled SEM[2]	137.5	0.0298	0.81

[1]A, B, and C represents dietary sodium level 0.15, 0.20 and 0.25 % respectively with sodium chloride as source; D, E and F represents dietary sodium level 0.15, 0.20 and 0.25 % respectively with sodium bicarbonate as source.
[2]Pooled standard error of means
[a-d]Means in a column and with no common letters differ significantly (P< 0.05)

Blood parameters

Sodium, chloride and bicarbonate concentrations in the blood are shown in Table IV. It is evident from the data that with the increasing level of sodium its concentration in the blood was increased significantly (P<0.05). Blood Na concentration showed a linear increase from low to high level of Na. This increase was more pronounced when Na was added in diet as sodium bicarbonate. Chloride concentration has significant (P<0.05) difference among the diets compared on the bases of source of sodium. However, when chloride concentration was compared within the same source and different level of sodium no difference was noticed. Same trend was observed with concentration of bicarbonate in the blood of birds fed different diets. There was no difference (P>0.05) among diets A, B, and C where sodium was added in different levels with sodium chloride as a source. However when these diets were compared with diets having sodium bicarbonate as sodium source it was revealed that there was significant (P<0.05) difference between the sources.

In the light of the results of present study it can be concluded that feeding higher sodium levels especially as sodium chloride for first two weeks may result in increase in body weight and feed efficiency but this effect did not persist till marketable age of broiler. Water consumption and blood sodium concentration has direct relationship with level of sodium in diet.

Table IV.- Effect of different sources and levels of sodium on blood parameters reared under low temperature from 1-42 days.

Treatment[1]	Sodium (mmol/L)	Chloride (mmol/L)	Bicarbonate (mmol/L)
A	142.9^{c}	110.9^{a}	25.4^{b}
B	146.6^{b}	111.1^{a}	25.5^{b}
C	149.8^{a}	110.7^{a}	25.4^{b}
D	141.2^{c}	106.3^{b}	26.2^{a}
E	148.1^{b}	105.7^{b}	26.6^{a}
F	149.9^{a}	105.6^{b}	26.5^{a}
Pooled SEM[2]	0.89	0.67	0.24

[1]A, B, and C represents dietary sodium level 0.15, 0.20 and 0.25 % respectively with sodium chloride as source; D, E and F represents dietary sodium level 0.15, 0.20 and 0.25 % respectively with sodium bicarbonate as source.
[2]Pooled standard error of means
[a-c]Means in a column and with no common letters differ significantly (P< 0.05)

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