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Effect of Potassium Chloride and Sodium Bicarbonate Supplementation on Thermotolerance of Broilers Exposed to Heat Stress

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Abstract: A total of 100-day-old broiler chicken were randomly divided into five groups and kept under elevated temperature (95-98.6°F) to observe the effect of potassium chloride and sodium bicarbonate on the weight gain, feed conversion ratio (FCR), serum potassium and serum bicarbonate level. Thermostress lead to significant in decrease ($P<0.05$) weight gain, serum potassium and serum bicarbonate level, while FCR was increased. During heat stress, KCl and NaHCO_3 at levels of 1.5% and 0.5% respectively, improved weight gain, and FCR and significantly increased ($P<0.05$) serum potassium and bicarbonate level. The results showed that combination of KCl and NaHCO_3 supplementation alleviated the negative effects of heat stress in broilers.

Key words: Potassium chloride, sodium bicarbonate, serum potassium, serum bicarbonate

Introduction

Poultry industry has occupied a leading role amongst agricultural industries in many parts of the world, as it is the major source of animal protein for human population. In Pakistan its importance can be judged from the fact that almost every family in rural areas and every fifth family in the urban areas is associated with poultry production activities (Anonymous, 2002).

In addition to various viral, bacterial, parasitic and fungal diseases, poultry farming is confronted with various non-infectious problems such as extreme environment, poor management and poor feed quality etc.

One of the major hazard challenging our poultry industry is the ambient temperature, which persists for about 5 months of the year (May to September) in most agro-ecological zones of Pakistan. During July and August, there is high temperature and low relative humidity, which results in hot humid climate, causing severe heat stress.

Heat stress limits the feed intake and growth potential of the chicken. Growth rate of commercial broilers after 3 weeks of age is usually maximal at 18 to 20°C and progressively declines in warmer conditions (Hurwitz *et al.*, 1980; Yahav *et al.*, 1996). In addition to reduced growth rates under warm climates increased mortality can occur at times when the ambient temperature increases for the short periods i.e. 5 to 10°C above the regular levels (Picard *et al.*, 1993).

The negative effects of high and low temperatures on poultry performance can be minimized by appropriate housing design, installation of cooling systems, feed formulation according to feed intake and weather conditions and use of electrolytes, vitamin C or aspirin in drinking water of birds (Brake *et al.*, 1994; Yahav and Planik, 1999).

Electrolytes are necessary to maintain physiological functions during hot weather (Brake *et al.*, 1994). These can be divided into cations and anions. Major cations are sodium, potassium calcium, and magnesium. While anions include principally bicarbonate, chloride, biphosphate and sulphate ions (McDonald *et al.*, 1999). Heat stress results in increased excretion of potassium through urine hence resulting in decreased plasma potassium (Ait-Boulahsen *et al.*, 1989; Keskin and Durgan, 1997). Therefore, dietary potassium level should be increased for birds reared in heat stressed environment. A level of 1.5 to 2% KCl as a source of potassium is needed to maximize gain in 5-8 weeks old broilers (Smith and Teeter, 1987).

In high temperatures birds regulate heat loss through evaporation of water from their lungs and this may precipitate respiratory alkalosis (Bottje and Harrison, 1985a; Kutlu, 1996). Heat exposed birds may exhibit reduced levels of plasma carbon dioxide and bicarbonate (Balnave and Gorman, 1993) and may affect the blood pH and induce in the birds a nutritional requirement for bicarbonate (Teeter *et al.*, 1985). Bonsembianate *et al.* (1988) reported that a level of 0.5% sodium bicarbonate, as a source of bicarbonate, stimulates the feed and water intake in broilers.

Therefore, this study was planned to elucidate the effect of potassium chloride and sodium bicarbonate administration separately and in combined form on weight gain, FCR and serum potassium and bicarbonate levels in heat exposed broilers.

Materials and Methods

The experiment was conducted at the experimental rooms of University of Veterinary and Animal Sciences, Lahore, under ambient temperature ranging from 95 to

Table 1: Weight gain and feed conversion ratio in birds of five groups

| Group | FCR on day 35 th | Average Body Weight | | Average Weight gain |
|-------|-----------------------------|---------------------|--------|----------------------|
| | | Day 1 | Day 35 | |
| A | 1.78 | 46.05 | 1525 | 1478.95 ^a |
| B | 2.14 | 48.53 | 1175 | 1126.47 ^b |
| C | 1.92 | 47.29 | 1375 | 1327.71 ^a |
| D | 1.90 | 45.44 | 1340 | 1294.56 ^a |
| E | 1.84 | 46.78 | 1475 | 1428.22 ^a |

Mean values having different superscripts within a column differ significantly (P<0.05)

98.6°F. For this purpose, one hundred, day-old broiler chicks were used. Those birds were randomly assigned into five groups, designated as A, B, C, D and E and weighed including 20 chicks in each, on 1st day of age. During 1st, 2nd and 3rd week of age, all the birds were kept at a temperature range of 90, 85 and 80°F.

But during 4th and 5th week of age, groups B, C, D and E were subjected to heat stress (95-98.6°F), while group A acted as control and was neither subjected to heat, nor supplemented with potassium chloride and sodium bicarbonate solutions. This group was kept at 75 and 70°F during 4th and 5th week of age. Group B was not supplemented either potassium chloride or sodium bicarbonate solution, during heat stress phase. Group C was supplemented with 1.5 KCl solution during heat stress period. Group D was supplemented with 0.5% NaHCO₃ solution during heat stress period. Group E was provided a combination of 1.5% potassium chloride and 0.5% NaHCO₃ solution during their heat stress period. All the birds were vaccinated against commonly prevalent diseases i.e. New Castle Disease, Gumboro disease and Hydropericardium syndrome.

Weight gain and FCR were calculated at 35th day of age. For determination of serum potassium and bicarbonate level by spectrophotometric method blood 5 samples were randomly collected from each group on day 21, 22, 23, 24, 29 and 30 of age.

The data thus obtained was analyzed statistically by one way analysis of variance and LSD test was applied to compare the means (Steel and Torrie, 1982).

Results and Discussion

In this study, birds of group A which were not exposed to heat stress revealed better weight gain than birds of group B, which were exposed to heat stress and given no electrolyte solution.

It means that heat stress resulted in decreased weight gain, when given no electrolyte solution. This finding was similar to earlier studies of Teeter *et al.* (1985), in hens and Keskin and Durgan (1997) in quails, who reported that, heat stress results in decreased weight gain.

Birds of group C, which were subjected to heat stress and supplemented with 1.5% KCl solution, exhibited a

better weight gain than birds of group B, which were exposed to heat stress and given no electrolyte solution. It shows that 1.5% KCl solution resulted in improvement of weight gain this finding was similar to the earlier studies of Keskin and Durgan (1997) in quails and Teeter *et al.* (1985), Lopez and Austic (1993), Branton *et al.* (1986), who reported that potassium chloride administration results in increase of weight gain in broilers exposed to heat stress.

This improvement in weight gain might be the fulfillment of potassium requirement, induced by respiratory alkalosis due to heat stress (Teeter *et al.*, 1985).

Birds of group D, which were subjected to heat stress and supplemented with 0.5% NaHCO₃ solution exhibited a better weight gain than birds of group B. It is similar to the earlier findings of Teeter *et al.* (1985), Balnave and Oliva (1991) and Balnave and Gorman (1993) in turkeys. This improvement might be due to bicarbonate anion provision. While these results differ from those obtained by Bottje and Harrison (1985b) in hens and Fuentes *et al.* (1998) in guinea fowls, who reported that body weight is not significantly increased by dietary sodium bicarbonate supplementation during heat stress.

Birds of group E which were exposed to heat stress during 4th and 5th week and supplemented with 1.5% KCl and 0.5% NaHCO₃ solution also exhibited better weight gain than birds of group B. This finding is similar to earlier studies of Kaskin and Durgan (1997) in quails and Lopez and Austic (1993) and Balnave and Gorman (1993) in hens. This beneficial effect might be due to the provision of potassium and bicarbonate ions. As heat stress created a dietary as well as physiological requirement for these ions (Teeter *et al.*, 1985).

Feed conversion ratio of birds of group A, which were not exposed to heat stress was better than birds of group B, C, D and E, which were exposed to heat stress. It shows, heat stress increased the FCR. This finding was similar to Keskin and Durgan (1995) and Sahoter *et al.* (1998), who reported that heat stress increased FCR.

The group C, which was subjected to heat stress during 4th and 5th week of age and supplemented with 1.5% KCl solution had better FCR than group B which was subjected to heat stress only. Similarly groups D and E, which were exposed to heat stress during 4th and 5th week of age and supplemented with 0.5% NaHCO₃ solution and a combination of 1.5% KCl and 0.5% NaHCO₃ solution exhibited a better FCR than group B. It was inferred that improvement in FCR of group C, D and E was due to potassium chloride sodium bicarbonate supplementation. Our findings are supported by those of Keskin and Durgan (1997), Bonsembianate *et al.* (1990) and Lopez and Austic (1993), who reported that potassium chloride and sodium bicarbonate improved FCR.

In the recent study, birds reared under normal conditions exhibited a serum potassium level significantly higher

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Table 2: Serum potassium level in broilers exposed to heat stress

| Group | Days | | | | | | |
|-------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| | 21 (meq/litre) | 22 (meq/litre) | 23 (meq/litre) | 24 (meq/litre) | 29 (meq/litre) | 30 (meq/litre) | 31 (meq/litre) |
| A | 5.16±0.31 ^a | 5.15±0.22 ^b | 5.13±0.22 ^c | 5.14±0.20 ^e | 5.11±0.16 ^g | 5.11±0.24 ⁱ | 5.10±0.1 ^k |
| B | 5.11±0.32 ^a | 4.91±0.15 ^b | 4.76±0.20 ^d | 4.73±0.19 ^f | 4.52±0.13 ^h | 4.49±0.21 ^j | 4.45±0.12 ^l |
| C | 5.10±0.10 ^a | 5.08±0.15 ^b | 5.11±0.19 ^c | 5.16±0.13 ^e | 5.20±0.14 ^g | 5.21±0.30 ⁱ | 5.21±0.38 ^k |
| D | 5.07±0.34 ^a | 4.99±0.14 ^b | 4.88±0.23 ^d | 4.80±0.12 ^f | 4.62±0.24 ^h | 4.55±0.24 ^j | 4.47±0.23 ^l |
| E | 5.08±0.50 ^a | 4.98±0.11 ^b | 5.01±0.10 ^c | 5.01±0.10 ^e | 5.07±0.16 ^g | 5.07±0.18 ⁱ | 5.10±0.24 ^k |

Values with different superscripts in the column differ significantly (P<0.05)

Table 3: Serum bicarbonate level in broilers exposed to heat stress

| Group | Days | | | | | | |
|-------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| | 21 (meq/litre) | 22 (meq/litre) | 23 (meq/litre) | 24 (meq/litre) | 29 (meq/litre) | 30 (meq/litre) | 31 (meq/litre) |
| A | 21.03±2.01 ^a | 20.71±1.05 ^b | 21.02±1.84 ^c | 21.16±1.85 ^e | 20.86±2.19 ^g | 20.52±1.94 ^k | 20.59±1.76 ^o |
| B | 20.98±1.02 ^a | 18.75±1.62 ^b | 16.48±1.27 ^d | 15.86±1.32 ^g | 11.39±0.65 ^j | 11.03±0.76 ^m | 10.90±0.51 ^p |
| C | 19.94±1.16 ^a | 17.40±0.73 ^b | 16.45±1.37 ^d | 13.57±1.08 ^g | 11.08±0.76 ⁱ | 10.83±0.30 ⁿ | 10.74±0.51 ^p |
| D | 22.04±1.62 ^a | 21.09±1.05 ^b | 20.47±0.81 ^c | 18.38±1.07 ^f | 15.58±1.16 ^h | 15.07±0.70 ⁱ | 14.56±0.81 ^o |
| E | 21.72±0.60 ^a | 21.01±0.60 ^b | 20.46±0.52 ^c | 19.24±0.64 ^f | 16.05±0.93 ^j | 15.48±0.80 ^j | 14.84±0.78 ^o |

Values with different superscripts in the column differ significantly (P<0.05)

than all thermostressed birds except, given 1.5% KCl solution and a combination of 0.5% NaHCO₃ and 1.5 KCl solution. This finding is similar to the earlier studies of Keskin and Durgan (1997) in quails.

Thermostressed (95-98.6°F) birds, administered no electrolyte solution, exhibited a serum potassium level significantly less than all other groups.

This finding is in accordance with the findings of Keskin and Durgan (1997), who reported that plasma potassium level is significantly decreased in quails during acute or chronic heat stress.

From above discussion it is clear than potassium level is decreased in serum during heat stress, and it might be due to the following reasons:

- (i) Potassium ions shift between muscle and extracellular fluid.
- (ii) Increased renal excretion of potassium.
- (iii) Increase in potassium ions uptake of erythrocytes and/or skin (Smith and Teeter, 1987; Ait Boulahsen *et al.*, 1989).
- (iv) A reduced competition between H⁺ and K⁺ ions for urinary excretion and thereby increased urinary potassium loss (Laiken and Fantasil, 1985).

Birds kept under heat stress (95-98.6°F) and given 1.5% potassium chloride solution exhibited a potassium level. Significantly higher than thermostressed group.

This finding is in accordance with Reece *et al.* (2000), who reported that, plasma potassium level in turkeys, is increased when dietary potassium level might be increased during heat stress. Same finding was reported by Keskin and Durgan (1997) in quails.

This improvement in serum potassium level is due to the compensation of it's deficiency by the provision of potassium ions (Reece *et al.*, 2000).

Birds exposed to heat stress (95-98.6°F) and given 0.5% NaHCO₃ solution exhibited no improvement in the

potassium level in the serum of broilers, and it was significantly less than the birds kept in thermoneutral environment.

This finding is in accordance with Keskin and Durgan (1997), who reported that quails exposed to heat stress and given 1% NaHCO₃ solution did not show any improvement in their plasma potassium level.

This might be due to the reason that potassium excretion from kidneys was increased and also their uptake was increased by erythrocyte and skin (Smith and Teeter, 1987), Ait Boulalisen *et al.* (1989), and potassium was not available in the diet to compensate this deficiency. So these birds did not show any improvement in their serum potassium level.

Thermostressed (95-98.6°F) birds given a combination of 0.5% NaHCO₃ and 1.5% KCl solution exhibited an improvement in their serum potassium level. It is in accordance with Keskin and Durgan (1997). This potassium level increase in serum might be due to the provision of K⁺ ions in the water (Reece *et al.*, 2000).

Birds reared in normal conditions, exhibited significantly higher serum bicarbonate level than all the birds exposed to ambient temperature. This finding is similar to the earlier studies of Keskin and Durgan (1997), in quails.

The chicks kept under heat stress (95-98.6°F) for two weeks and given no electrolyte solution, exhibited a decreased serum bicarbonate level.

This finding is similar to the findings of Balnave and Gorman (1993); who reported that, "broilers kept under heat stress might exhibit reduced levels of plasma carbon dioxide and bicarbonate during panting". Keskin and Durgan (1997), also reported that, "acute heat stress results a sharp decline in blood CO₂ partial pressure, accompanied by a fall in blood bicarbonate with the increase in pH in quails".

From above discussion, it is concluded that, during heat stress bicarbonate level in broilers is decreased. It might be due to the reason that, in heat stress panting was increased in broilers, resulting into hyperventilation (Teeter *et al.*, 1985) and this increased ventilation stopped the regeneration of bicarbonate. As normal plasma HCO_3 level depends upon the daily regeneration as well as re-absorption of all bicarbonate filtered across the glomerular capillaries, so this resulted into a decrease in plasma HCO_3 (Kumar and Clark 2002).

Chicks kept under heat stress and given 1.5% KC1 solution exhibited significantly less than other birds exposed to heat stress bicarbonate level. It means 1.5% KC1 solution did not compensate the bicarbonate deficiency. This finding is similar to that of Keskin and Durgan (1997), who reported that, "quails given 1% KC1 solution exhibited a reduced bicarbonate level.

Serum bicarbonate level of chicks kept in heat stress and given 0.5% NaHCO_3 solution, bicarbonate level was significantly higher than the birds exposed to heat stress and given either no electrolyte solution or 1.5% KC1 solution.

This finding is in accordance with Keskin and Durgan (1997), who reported that bicarbonate level is improved in quails, exposed to heat stress, when given 1% NaHCO_3 in diet, as compared to the group given basal diet and 1% KC1 in diet.

The reason for this significant increase in HCO_3 level might be the provision of bicarbonate anion. As it's physiological requirement was fulfilled (Keskin and Durgan, 1997).

Thermostressed broiler birds provided with 0.5% NaHCO_3 solution and 1.5% KC1 solution exhibited a bicarbonate level significantly higher than thermostressed birds given no electrolyte solution and 1.5% KC1 solution. This finding is in accordance with Keskin and Durgan (1997).

The reason for the compensation of HCO_3 level in the serum might be the provision of bicarbonate anion. As it's physiological requirement was fulfilled (Keskin and Durgan, 1997).

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