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USING SODIUM BICARBONATE AND AMMONIUM CHLORIDE IN BROILER CHICK DIETS TO ALLEVIATE HEAT STRESS IN EGYPT

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SUMMARY

A total number of 210 one week old Avian broiler chicks were used to study the effect of sodium bicarbonate and ammonium chloride supplementation on performance and some physiological parameters of the broilers during hot summer season (27.6-35.6°C). The study was carried out during June and July. Broilers were fed on the control diet containing 23% CP and 3100 Kcal ME/Kg diet from 1-4 weeks of age and 18% CP and 3200 Kcal ME/Kg from 4-7 weeks of age (NRC recommendation).This diet was supplemented with two levels (1 and 2%) of either NaHCO3, NH4Cl or a mixture of them (50:50), in addition to such control diet without supplementation. Therefore , the total birds were divided into 7 treatments, each containing 30 birds in three replicates.

The results showed that addition of either 1% $NaHCO_3$ or 2% of a mixture of $NaHCO_3$ and NH_4Cl (50:50) to broiler chick diets recorded the highest performance and economic efficiency of production compared to control diet (without supplementation). The worst values were obtained by feeding broiler chicks on diet supplemented with 2% NH_4Cl. The values of body temperature, blood pH, plasma Na and K concentration and mortality rate were nearly similar and were not affected by the treatments. Accordingly, it is preferable to supplement NRC recommendation diet with 1% sodium bicarbonate to obtain the best broilers performance during hot summer season.

Keywords: Broiler, performance, physical characteristics, heat stress, $NaHCO_3$, NH_4Cl

INTRODUCTION

Numerous chemical compounds have been added to broiler diet or drinking water in an attempt to alleviate the adverse effects of heat stress. Bottje and Harrison (1985); Fixter *et al.* (1987); Balnave and Oliva (1991); Balnave and

Gorman (1993) and Ahmed and Maghraby (1995) observed that adding $NaHCO_3$ at levels ranged between 0.16 to 1.0% to broiler chick diets significantly increased body weight, weight gain, feed intake, feed efficiency and decreased body temperature, blood pH, panting rate and mortality rate during heat stress (32°C). While, Teeter *et al.* (1985); Damron *et al.* (1986) and Smith and Teeter (1993) fed broiler chicks on diets containing different levels of ammonium chloride (NH_4Cl) from 0.3 to 3.0% under heat stress (32°C). They found that the level of 0.3 or 1.0% NH4Cl increased body weight gains by 9.5 and 25%, respectively. While, 3% NH_4Cl elevated weight gains by only 8%. The objective of the present study was to detect the effect of either sodium bicarbonate, ammonium chloride or a 50:50 mixture of them as anti – heat stress agents on the performance of broilers under hot conditions .

MATERIALS AND METHODS

A total number of 210 unsexed week old avian broiler chicks were used. The birds were randomly distributed into 7 treatments, each contained 30 birds in three replicates. Birds were kept in wire floored batteries in an open system house under the same managerial conditions. Water and feed were offered ad- libitum and artificial lighting was provided 24 hours daily allover the experimental period which lasted for 7 weeks of age. Birds were fed on the control diet containing the NRC requirements of protein 23 and 18 % CP and energy 3100 and 3200 K cal ME/Kg for growing (1-4 weeks of age) and finishing (4-7 weeks of age) periods, respectively. The control diet was supplemented with one of the three chemical compounds ($NaHCO_3$, NH_4Cl or 50:50 mixture of them). Each chemical compound was added at two levels (1 or 2% of the diet). The experimental diets and their chemical composition are presented in Tables 1 and 2. The maximum and minimum ambient temperature recorded daily at noon (12:00 p.m.). Table (3) shows the mean ambient temperature and relative humidity during the experimental period (2-7 weeks of age). The ambient temperature ranged between 27.0 and 35.6°C and relative humidity was between 50 and 54% . Birds were weighed and feed consumption was recorded during the experimental period to calculate body weight gain and feed conversion. Economic efficiency was also calculated. Body (skin) temperature was recorded four times weekly at noon (12:00 p.m.) by inserting a digital electric thermometer under the wing, while the rectal (deep body) temperature, was measured from the cloaca. Respiration rate (panting) was counted also four times weekly by observing the movement of the abdomens for one minute at noon. Blood pH was determined by using a digital electric pH meter immediately after blood sample collection. The spectrophotometric technique according to Henry (1974) was used to determine sodium and potassium concentration in the plasma. The proximate analysis of feed was carried out according to the official methods

(AOAC, 1990). Data from all the response variables were subjected to a factorial and one way analysis of variances (SAS, 1990). Those variables having a significant F-test were compared using Duncan's multiple range test (Duncan, 1995).

Table 1. The percentage composition of experimental diets used during the growing period (1-4 weeks)

Diets		1	2	3	4	5	6	7
Ingredients								
Corn		56.50	54.25	52.00	54.25	52.00	54.25	52.00
Soybean meal (44 %)		22.00	22.50	23.00	22.50	23.00	22.50	23.00
Fish meal (70 %)		4.50	4.50	4.50	4.50	4.50	4.50	4.50
Protein concentrate (60 %)		10.00	10.00	10.00	10.00	10.00	10.00	10.00
Oil		4.00	4.75	5.50	4.75	5.50	4.75	5.50
NaH CO_3			1.00	2.00			0.50	1.00
NH_4 CL					1.00	2.00	0.50	1.00
Bone meal	(1)	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Vit.&Min. Premix		0.25	0.25	0.25	0.25	0.25	0.25	0.25
Salt		0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total		100.00	100.00	100.00	100.00	100.00	100.00	100.00
Determined values								
CP	%	23.41	23.54	23.35	23.5	23.52	23.45	23.61
EE	%	8.17	8.35	9.1	8.7	8.95	8.56	8.93
CF	%	3.25	3.14	3.17	3.07	3.21	3.52	3.45
Calculated values								
ME (Kcal / Kg)		3104	3106	3107	3106	3107	3106	3107
C / P ratio		135	135	135	135	135	135	135
Ca	%	0.92	0.92	0.92	0.92	0.92	0.92	0.92
P (total)	%	1.04	1.04	1.03	1.04	1.03	1.04	1.03
P (Avail)	%	0.53	0.53	0.53	0.53	0.53	0.53	0.53
Methionine	%	0.66	0.66	0.66	0.66	0.66	0.66	0.66
Lysine	%	1.36	1.37	1.37	1.37	1.37	1.37	1.37
Cystine	%	0.32	0.32	0.32	0.32	0.32	0.32	0.32
Meth.+cyst.		0.98	0.98	0.98	0.98	0.98	0.98	0.98
Price L.E / ton		1280	1300	1320	1300	1320	1300	1320

(1) Supplies per Kg diet :

Vitamin A 13000 I.U., Vit D_3 2000 I.U.,Vit E10 mg , Vit K 2 mg, Vit B_1 2 mg , Vit B_2 4mg , Vit B_6 1.5 mg, Vit B_{12} 12 mg , Pantothenic acid 10 mg , Nicotinic acid 20 mg , Folic acid 1 mg , Biotin 0.05 mg , Choline chloride 500 mg , Copper 10 mg , Iodine 1 mg , Manganess 55 mg , Zinc 55 mg , Selenium 0.15 mg , Cobalt 0.25 mg and Iron 30 mg .

Table 2. The percentage composition of experimental diets used during the finishing period (4-7 weeks)

Diets Ingredients	1	2	3	4	5	6	7
Corn	66.50	64.25	62.00	64.25	62.00	64.25	62.00
Soybean meal (44 %)	16.00	16.50	17.00	16.50	17.00	16.50	17.00
Protein concentra (60 %)	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Oil	4.50	4.25	6.00	5.25	6.00	5.25	6.00
$NaH\ CO_3$		1.00	2.00			0.50	1.00
$NH_4\ CL$				1.00	2.00	0.50	1.00
Bone meal (1)	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Vit.&Min. Premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Determined values							
CP %	18.20	18.58	18.48	18.2	18.55	18.54	18.63
EE %	8.97	9.37	9.65	8.94	9.48	9.35	9.33
CF %	3.64	3.28	3.59	3.34	3.51	3.67	3.51
Calculated values							
CP %	18.09	18.11	18.13	18.11	18.13	18.11	18.13
ME (Kcal / Kg)	3206	3207	3209	3207	3209	3207	3209
C / P ratio	177	177	177	177	177	177	177
EE %	7.75	8.42	9.09	8.42	9.09	8.42	9.09
CF %	2.83	2.82	2.81	2.82	2.81	2.82	2.81
Ca %	0.80	0.81	0.81	0.81	0.81	0.81	0.81
P (total) %	0.95	0.95	0.95	0.95	0.95	0.95	0.95
P (Avail) %	0.46	0.46	0.46	0.46	0.46	0.46	0.46
Methionine %	0.55	0.54	0.54	0.54	0.54	0.54	0.54
Lysine %	0.95	0.96	0.97	0.96	0.97	0.96	0.97
Cystine %	0.26	0.26	0.26	0.26	0.26	0.26	0.26
Meth.+cyst.	0.81	0.80	0.80	0.80	0.80	0.80	0.80
Price L.E / ton	1150	1170	1190	1170	1190	1170	1190

(1) Supplies per Kg diet: Vitamin A 13000 I.U., Vit D_3 2000 I.U.,Vit E10 mg , Vit K 2 mg, Vit B_1 2 mg , Vit B_2 4mg , Vit B_6 1.5 mg , Vit B_{12} 12 mg , Pantothenic acid 10 mg, Nicotinic acid 20 mg , Folic acid 1 mg , Biotin 0.05 mg , Choline chloride 500 mg, Copper 10 mg , Iodine 1 mg , Manganess 55 mg , Zinc 55 mg , Selenium 0.15 mg, Cobalt 0.25 mg and Iron 30 mg.

Table 3. The mean ambient temperatures and relative humidity during the experimental period.

Weeks	Ambient temperature °C		Relative Humidity (%)
	Maximum	Minimum	
2	35.0 ± 0.8	28.0 ± 0.9	54
3	35.7 ± 2.4	28.4 ± 0.8	51
4	35.6 ± 0.9	27.6 ± 1.1	53
5	35.9 ± 1.8	27.4 ± 1.5	52
6	35.6 ± 1.5	27.0 ± 0.8	52
7	35.6 ± 0.8	27.4 ± 0.5	50

RESULTS AND DISCUSSION

Data in Table (4) showed that using $NaHCO_3$ (S1) improved significantly the average values of body weight, weight gain, feed intake and feed conversion followed by using a 50:50 mixture of $NaHCO_3$ and NH_4Cl (S3). While, the worst values were recorded when broiler chicks were fed on diet supplemented with NH_4Cl (S2). Regardless of source of the chemical compounds, the low level (L1) of the chemical compound (1%) gave better performance than L2(2%). The interaction between electrolyte source and level (SxL) indicated that the best performance was for the birds fed on the diet which supplemented with 1% $NaHCO_3$ or a 50:50 mixture of $NaHCO_3$ and NH_4Cl at either 1 or 2%. While, the worst performance and economic efficiency values were for the birds fed on the diet which supplemented with NH_4Cl at 2% level. Balnave and Gorman (1993) attributed the improvement in feed intake to the bicarbonate ion which produce cation - anion balance or dietary electrolyte balance, thereby the body weight and weight gain increased. These results agree with those of Damron *et al.* (1986); Fixter *et al.* (1987) and Ahmed and Maghraby (1995) who found that the average values of body weight, weight gain and feed intake were significantly increased by feeding broiler chicks on diets supplemented with different levels of $NaHCO_3$ (from 0.2 to 1.6%) under heat stress (32°C) compared to those fed on diet without $NaHCO_3$ supplementation. Also, Teeter *et al.* (1985) found that adding NH_4Cl or a mixture of $NaHCO_3$ and NH_4Cl to broiler diets at level of 0.5% improved broilers performance under heat stress (32°C). On the contrary to the results of this study. Bottje and Harrison (1985) found that adding 1.0% $NaHCO_3$ to the grower diet for cockerels which were reared under heat stress had no effect on growth rate. Also, Smith and Teeter (1993) observed that broiler performance was not influenced by adding NH_4Cl to broiler diet under heat stress. Table (5) showed that the average values of body temperature, rectal temperature, panting rate, blood pH and plasma Na and K were nearly similar and without significant differences due to electrolyte source. while, body temperature, rectal temperature, panting rate and blood pH were slightly decreased, not significantly, at 2% (L2) compared to 1% (L1) supplementation. The interaction between S x L indicated that the average values of body temperature, rectal temperature and blood pH were slightly decreased when broiler chicks were fed on diets supplemented with different levels (1 or 2%) of different sources of electrolytes compared to control diet (without supplementation). Panting rate was decreased significantly due to the addition of either S1,S2 or S3 especially at 2% (L2). The average values of plasma Na and K concentration were nearly similar and not affected by different treatments. The decrease in body temperature and panting rate may be due to the increase in water consumption. The results of this study were in agreement with those obtained by Teeter and Smith (1986); Balnave and

Table 4. Effect of different treatments on broiler performance and economic efficiency

No	Treatment S	Treatment L	Initial body weight (g)	Final body weight (g)	Weight gain(g)	Feed intake(g)	Feed conversion	E.E	Relative E.E
1	S1		144	1965±21.30	1822±7.37	3859±5.91	2.12±0.03		
2	S2		143	1720±54.31	1577±54.30	3507±74.97	2.23±0.03		
3	S3		144	1934±34.16	1790±34.10	3810±15.31	2.13±0.04		
1		L1	145	1926±23.98	1783±23.95	3815±20.37	2.14±0.03		
2		L2	144	1819±49.58	1676±49.46	3634±63.92	2.18±0.03		
1	S0	L0	145	1753±4.91	1609±4.93	3717±14.57	2.31±0.02	0.45	100
2	S1	L1	142	1887±6.51	1745±7.02	3911±2.33	2.24±0.01	0.51	113
3	S1	L2	144	1904±8.35	1761±7.69	3862±26.91	2.19±0.01	0.51	113
4	S2	L1	143	1805±5.00	1662±6.36	3719±24.69	2.24±0.01	0.49	109
5	S2	L2	142	1503± 6.11	1361±5.36	3176±19.09	2.33±0.01	0.37	82
6	S3	L1	144	1811±10.27	1667±10.17	3815±25.24	2.29±0.03	0.47	104
7	S3	L2	143	1831±3.21	1688±3.21	3745±10.69	2.22±0.01	0.47	109

Means in each column, within each item , bearing the same superscripts do not differ significantly ($P > 0.05$)

(1) Net revenue per unit cost .

(2) Assuming that the relative E.E of group (1)=100

Gorman (1993); Ahmed and Maghraby (1995) and Osman (1996) who found that adding either $NaHCO_3$ or NH_4Cl to broiler chick diets or drinking water under heat stress significantly decreased body temperature and panting rate values compared to control group (without supplementation). The slight decrease in blood pH values with adding either $NaHCO_3$, NH_4Cl or a mixture of them to broiler chick diets may be attributed to the HCO_3 and Cl ions as indicated by Balnave and Gorman (1993) who showed that the carbon dioxide (CO_2) is an end product of oxidative metabolism in tissues and is converted to carbonic acid (H_2CO_3) through the action of the enzyme carbonic anhydrase. Carbonic acid is a source of bicarbonate ion (HCO_3) and is involved directly in the anabolic reactions. Also, bicarbonate ion is a component of the bica/ carbonic acid buffer system. Also, Teeter *et al.* (1985); Branton *et al.* (1986); Ahmed and Maghraby (1995) and Osman (1996) found that the blood pH values were decreased when broiler chicks were reared under heat stress and supplied their diet or drinking water with either $NaHCO_3$ or NH_4Cl.

Table 5. Effect of treatments on physical characteristics

No	Treatment S	Treatment L	Body Temp.	Rectal Temp.	Panting rate	Blood pH	Plasma Na(ppm)	Plasma K(ppm)
1	S1	--	40.95±0.03	41.57±0.03	104±1.64	7.80±0.01	124±0.60	16±0.50
2	S2	--	40.95±0.04	41.61±0.03	104±1.59	7.80±0.01	124±0.34	16±0.18
3	S3	--	40.85±0.04	41.61±0.02	102±1.47	7.75±0.02	124±0.29	16±0.16
1	--	L1	40.92±0.03	41.62±0.02	105±1.23	7.79±0.01	124±0.42	16±0.34
2	--	L2	40.91±0.03	41.57±0.02	103±1.23	7.78±0.01	124±0.34	16±0.16
1	S0	L0	41.07±0.03	41.77±0.07	116±2.33	7.89±0.01	124±0.46	16±0.20
2	S1	L1	40.87±0.03	41.67±0.07	106±3.05	7.84±0.07	123±0.33	17±0.40
3	S1	L2	40.90±0.06	41.43±0.07	100±2.89	7.78±0.04	125±1.24	17±0.33
4	S2	L1	41.00±0.10	41.57±0.09	108±1.45	7.84±0.02	123±0.42	17±0.23
5	S2	L2	40.83±0.03	41.57±0.03	103±3.33	7.69±0.06	125±0.55	16±0.29
6	S3	L1	40.77±0.03	41.67±0.03	101±2.08	7.78±0.02	123±0.34	16±0.13
7	S3	L2	40.73±0.03	41.57±0.03	98±1.67	7.76±0.01	123±0.34	16±0.32

Means in each column, within each item , bearing the same superscripts do not differ significantly ($P > 0.05$)

It could be concluded that using the NRC recommendation diet supplemented with 1% $NaHCO_3$ had a significant effect on improving the performance and economic efficiency of the broiler chicks during hot summer season of Egypt.

REFERENCES

Ahmed, N. A. and N.A. Maghraby, 1995. Physiological response of broilers to dietary sodium bicarbonate during summer season. Egypt. J. Anim. Prod. 31 : 271-275.

Association of Official Agricultural Chemists, 1990. "Official Methods of Analysis" 15 Ed.Published by the A.O.A.C.;Washington;D.C.

Balnave, D. and I. Gorman, 1993. A role for sodium bicarbonate supplements for growing broilers at high temperatures .World's Poultry Sci., J. 49: 236-241.

Balnave, D. and A.G.Oliva, 1991. The influence of sodium bicarbonate and sulphur amino acids on the performance of broilers at moderate and high temperatures. Australian. J. of Agric. Res. 42 : 1385-1397.

Bottje, W.G. and P.C. Harrison, 1985.The effects of tap water , carbonated water, sodium bicarbonate, and calcium chloride on blood acid -base balance in cockerels subjected to heat stress. Poultry Sci.64:107-113.

Branton, S.L., F.N. Reece and J.W. Deaton, 1986. Use of ammonium chloride and sodium bicarbonate in acute heat exposure of broilers. Poultry Sci. 65 : 1659 - 1663.

Damron, B.L., W.L. Johnson; and L.S. Kelly, 1986. Utilization of sodium bicarbonate by broiler chicks. Poultry Sci., 65:782.

Duncan, D.B., 1955. The multiple range and F-tests Biometrics. 11:1-45.

Fixter, M.; D. Balnave; and R.J. Johnson, 1987.The influence of dietary electrolyte balance on broiler growth at high temperatures. Proceedings of the Poultry Husbandry Research Foundation Symposium, University of Sydney, PP. 34-48.

Henry,R.J., 1974. Clinical Chemistry.Harper & Row, New York, 2 Ed.644-646.

N.R.C.,1984. National Research Council. Nutrient Requirements of poultry. 7Ed. National Academy of Sciences. Washington; D. C.; U. S. A.

Osman, A. O. A., 1996. Effect of heat stress and salts on blood picture of chicken during rearing period. M.Sc. Thesis, Fac. Agric. Cairo Univ.

SAS Institute, 1990. SAS/STAT User's Guide, Version 6.4 Ed. SAS Institute Inc., Cary, NC.

Smith, M. O.; and R. G. Teeter, 1993. Effects of feed intake and environmental temperature on chick growth and development. J. Agric. Sci., 121: 421 - 425.

Teeter, R. G. and M. O. Smith, 1986. High chronic ambient temperature stress effects on broiler acid - base balance and their response to supplemental ammonium chloride, potassium chloride, and potassium carbonate. Poultry Sci. 65: 1777 - 1781.

Teeter, R. G., M. O. Smith F.N. Owens, S. C. Arp, S. Sangiah and J. E. Breazible, 1985. Chronic heat stress and respiratory alkalosis : occurrence and treatment in broiler chicks. Poultry Sci. 64 : 1060 - 1064.

إستخدام بيكربونات الصوديوم وكلوريد الأمونيوم في علائق بداري التسمين لتقليل الإجهاد الحراري خلال فصل الصيف في مصر

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تم تقسيم عدد ٢١٠ كتكوت تسمين عمر أسبوع إلى ٧ مجموعات تجريبية لدراسة تأثير إضافة بيكربونات الصوديوم وكلوريد الأمونيوم على الأداء الإنتاجي وبعض الخصائص الفسيولوجية لدجاج التسمين خلال فصل الصيف (٢٧,٦-٣٥,٦°م) خلال شهرى يونيو و يوليو . في هذه الدراسة تم إستخدام عليقة المقارنة (كنترول) وهى عبارة عن العليقة التي تحتوي على الإحتياجات الغذائية لبدارى التسمين وفقاً لتوصيات الـ NRC وهي ٢٣٪ بروتين خام و ٣١٠٠ كيلو كالوري طاقة ممثلة /كجم خلال فترة النامي (١-٤ أسابيع من العمر)، ١٨٪ بروتين خام و ٣٢٠٠ كيلو كالوري طاقة ممثلة /كجم خلال فترة الناهي (٤-٧ أسابيع من العمر) . وقد تم إستخدام العليقة السابقة إما بدون إضافة أو مع إضافة بيكربونات الصوديوم أو كلوريد الأمونيوم أو مخلوط منهما (١:١) بمستوى ٢،١ ٪ من العليقة . أوضحت نتائج هذه التجربة أن إضافة بيكربونات الصوديوم بمستوى ١٪ أو مخلوط من بيكربونات الصوديوم وكلوريد الأمونيوم (بنسبة ١: ١) بمستوى ٢٪ إلى علائق بداري التسمين أعطى أعلى معدل إنتاجي للطيور وأعلى كفاءة إقتصادية مقارنة بعليقة المقارنة (بدون إضافة). أدى أيضاً إضافة بيكربونات الصوديوم وكلوريد الأمونيوم إلى إنخفاض معدل النهجان وتركيز أيون الهيدروجين ودرجة حرارة الجسم وخاصة عند إضافة المستوى العالي (٢٪) بينما لم يتأثر تركيز كلاً من الصوديوم والبوتاسيوم في بلازما الدم بالمعاملات المختلفة.
وعلى ذلك يفضل إضافة ١٪ من بيكربونات الصوديوم إلى العليقة الاساسية لبدارى التسمين لتقليل الإجهاد الحرارى خلال فصل الصيف فى مصر .