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EFFECT OF ELECTROLYTE *(ALMARIL PLUS)* ON BROILERS EXPOSED TO HIGH ENVIRONMENTAL TEMPERATURE

(With 8 Tables)

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تأثير المادة المتأينة (ألماريل بلاس) على دجاج التسمين المعرض لجو درجة حرارته عالية

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أجريت تجربتان لإختبار نظرية أن الدجاج الذى يشرب ماء يحتوى على المادة المتأينة (ألماريل بلاس) بها بوتاسيوم قبل أو أثناء التعرض لعامل الإجهاد الحرارى الحاد أو المزمن يكون أكثر تحملاً من الدجاج الذى يشرب ماء فقط. أجريت التجربة الأولى على دجاج تعرض لعامل الإجهاد الحرارى الحاد مرتين عند عمر ٢٥، ٣٥يوم، والتجربة الثانية على دجاج تعرض لعامل الإجهاد الحرارى المزمن مرة واحدة عند عمر ٤١-٤٣ يوم. كل تجربة قسمت إلى خمس مجاميع: دجاج شرب ماء فقط (كنترول) ، أو تعرض للحرارة وشرب ماء فقط ، أو تعرض للحرارة وشرب ماء يحتوى على المادة المتأينة (ألماريل بلاس) بتركيزات مختلفة ٠,٦٢٥، ١,٢٥، ٢,٠٠ مللى مادة متأينة / لتر ماء مقطر . تم حساب كمية الماء والأكل المستهلكة ونسبة الوفيات ووزن الجسم بالإضافة إلى نسبة البوتاسيوم والكالسيوم والفوسفور فى السيرم. وأظهرت النتائج زيادة فى كمية الماء والأكل مع كل التركيزات السابقة. بالنظر إلى معدل الوفيات أعطى التركيز ٢ مللى مادة متأينة / لتر ماء مقطر أفضل نتيجة حيث لم تحدث وفيات عند عمر ٢٥، ٤١ - ٤٣ يوم وعند عمر ٣٥ يوم كانت أقل نسبة وفيات. تم تسجيل وزن الجسم أسبوعيا وكان أعلى وزن عند عمر ٦ أسابيع بإستخدام التركيز ٢ مللى . لم يتأثر مستوى البوتاسيوم فى السيرم مع التركيز ٢ مللى عند عمر ٣٥ يوم، أما عند عمر ٤١ - ٤٣ يوم زادت نسبة البوتاسيوم معنوياً. أعطى التركيز٢ مللى أعلى نسبة كالسيوم (فى حدود النسبة العادية) فى التجربتين. زاد الفوسفور معنوياً عند عمر ٢٥، ٤١ - ٤٣ يوم مع جميع التركيزات، أما عند ٣٥ يوم فكانت أعلى زيادة مع التركيز ١,٢٥مللى.

SUMMARY

Two experiments were designed to test the hypothesis that chickens which drink on electrolyte solution *(Almaril Plus)* containing potassium as (citrate and dihydrogen orthophosphate) just prior and during an acute or / and chronic exposure to heat stress (HS), would have greater thermotolerance than chickens that consume only water . In two experiments (I and II) at 25 & 35 day (experiment I) and 41 - 43 day old chickens (experiment II) drank tap water (control), or exposed to heat and drank water only , or exposed to heat and drank water contains 0.625, 1.25 and 2.00 ml electrolyte solution *(Almaril Plus)* / liter distilled water for 4 hours before HS and 6 hours after HS. Water and food consumption, mortality rate, body weight, Serum K, Ca and P were determined. Water and food intake increased with all concentrations in the two experiments. The concentration of 2.00 ml/ liter gave the lowest mortality rate at the age of 35 d. old chickens, and no mortalities occurred with this concentration at 25 and 41 - 43 d.. Body weight (BW) was recorded weekly and 2.00 ml concentration gave the highest BW at six weeks old. The results showed that 2.00 ml concentration had no significant changes in K level at 35 d. old but showed significant increase at 41 - 43 d. old . The concentration of 2.00 ml increased Ca significantly (within normal limit) at the two experiments. At 25 and 41 - 43 d. old chickens P increased significantly (within normal limit) at all concentrations, but at 35 d. old P significantly increased with the concentration of 1.25 ml only.

Key words : Heat stress-chickens - mortality - electrolytes.

INTRODUCTION

High temperature in summer causes heat stress in all breeds of poultry. Acute heat exposure caused low feed intake and weight gain reduction (Teeter et al., 1985), and increased in mortalities (Reece et al., 1972). The causes of these undesirable changes were under constant investigation and reasons include changes in intestinal flora (Suzuki et al., 1983), amino acid digestibility (Wallis and Beinave, 1984), and blood electrolyte balance (Mitchell and Siegal, 1973).

In order to counteract these changes, various management practices have been used, but with mixed results. One practice that has been quite

effective is the addition of electrolytes in the form of potassium chloride (KCl) and sodium chloride (NaCl) to the drinking water (Smith and Teeter, 1989) which increased weight gain and livability.

Potassium, the most abundant intracellular cation, involved in many metabolic processes, including nerve conduction, excitation - contraction in muscle cells and regulation of cell volume (Ait-Boulahsen et al., 1995). Consequently changes in potassium (K) haemostasis profoundly affect cellular function (Koufman and Papper, 1983; Thier, 1986). Heat stress depresses plasma K concentration in chickens (Huston, 1978; Ait-Boulahsen et al., 1989; Belau and Teeter, 1996), enhances urinary potassium excretion, and reduces body K retention (Deetz and Ringrose, 1976; Smith and Teeter, 1987). This lead to inadequate cellular K status if an appropriate amount of K was not provided. Indeed, dietary K level of 1.5% for broiler chickens (Smith and Teeter, 1987) was needed to prevent a k imbalance under conditions of chronic heat stress.

High environmental temperature has a large influence on water intake (North and Bell, 1990). This response may be potentiated by high K intake, as k is known to stimulate water consumption (Austic, 1979).

Growth improvement of poultry at high temperature had been reported by Teeter (1988) with any one of a range of electrolytes (NH_4Cl, KCl, NaCl and K_2SO_4) added to the drinking water.

This study was designed to investigate possible interaction between different levels of K (K citrate and K dihydrogen orthophosphate) in drinking water of broilers exposed to acute or chronic heat stress on : Water and feed consumption, mortality rate, body weight and plasma electrolyte status.

MATERIAL AND METHODS

Three hundred, one day old commercial broilers were divided into ten groups each contained 30 chickens (divided into double replicated groups). All chickens were reared on litter floor (wood shave) and fed a corn soy-bean diet. All chickens consumed food and water *ad libitum* during 43 days of age.

In this experimental work, a product consists of electrolytes produced by Neolate products Paris *(Almaril Plus)* was used. It is light yellow transparent viscous liquid supplement and composed of NaCl, K citrate, K dihydrogen orthophosphate, glycine, dextrose and citric acid. The

percentage of electrolytes is Na 3.9%, K 1.4% and P 1.2%. *Almaril Plus* dissolved in distilled water.

150 chickens (experiment I) were exposed to acute heat stress (at 25 and 35 days old respectively). Temperature increased progressively from 24°C to 29°C over a 30 min. period, then from 29°C to 37°C at a rate of 4°C / hour. After 90 min. of exposure to 37°C, the temperature was increased within 30 min. to 39°C for 6 hours. Relative humidity was maintained at 35% to 55%.

150 chickens (experiment II) were exposed to chronic heat stress at 39°C for 6h. every day (as exp. I) for 3 successive days at 41, 42 and 43 days old.

Drinking water and feed were offered *ad libitum* during heat exposure (whether acute or chronic).

The experimental design is summarized in Table (1). Control groups (1) maintained under ordinary temperature 22-24°C all times and drank water only (-ve control). Control groups (2) exposed to heat stress and drank water only (+ ve control). Experimental groups (3, 4 and 5) exposed to HS and drank water contained electrolyte solution (*Almaril Plus)* by different concentrations.

Table 1: Summary of the experimental work.

Experiments	Groups	No. of birds / group	Doses of *(Almaril Plus)*/ liter dis. water	Heat stress (HS)
I	1	30	-	Acute heat stress
	2	30	-	
	3	30	0.625 ml	
	4	30	1.25 ml	
	5	30	2.00 ml	
II	1	30	-	chronic heat stress
	2	30	-	
	3	30	0.625 ml	
	4	30	1.25 ml	
	5	30	2.00 ml	

Water consumption, feed intake and mortality rate were recorded in the two experiments on the day of high temperature. Body weight (BW) was recorded weekly. Blood samples of 3 ml were taken from the wing vein of 10

chickens / group 4 hours prior to heat exposure and 6h. after heat exposure. Serum was separated and used for determination of potassium (K), calcium (Ca) and phosphorus (P) according to Sunderman and Sunderman (1958), Sarkar and Chanhan (1967) and Goodwin (1970); respectively.

Results of these parameters were statistically analyzed (F-test) according to Snedecor and Cochran (1967) using MSTAT-C computer program. Means followed by different letters are significantly differed and the highest value was represented with the letter "a".

RESULTS

Experiment I : Effect of heat and electrolyte solution at 25 & 35 d. old chickens during acute HS exposure:

The effect of heat exposure (gp. 2) on water and feed consumption at 25 d. old is shown in Table (2). Water consumption increased by 16.5% while feed consumption decreased by 14.29% compared with (1st gp.) Addition of electrolyte solution led to increase water consumption, the highest ratio was 32.5% in gp.5 compared with 1st gp., also increase feed consumption by 76% in gp. 4 compared with 1st gp. All five groups had no mortalities (Table,2).

The effect of heat exposure (gp.2) on water and feed consumption at 35 d. old is shown in Table (3). Water consumption increased by 3.75%, while feed consumption decreased by 8.57% compared with 1st gp. Addition of electrolyte solution led to increase water and feed consumption, the highest ratios were 43.33% and 78.57% respectively in gp. 4 compared with 1st gp.. Regarding mortality rate as shown in Table (3), groups 2,3 and 4 recorded the highest mortality rate by the ratio of 16.67%, while 5 th gp. gave the best result (6.67%) compared with 1st gp.

Insignificant decrease in body weight due to heat exposure (gp.2) at four weeks old (Table, 5). Addition of electrolyte solution to drinking water led to a significant increase in BW. The three concentrations of electrolyte solution gave the same result Table (5). The effect of heat exposure (gp.2) on body weight was significant as it decreased at five weeks old compared with 1st gp. Addition of electrolyte solution led to a return of BW to control level (1st gp.) as shown in Table (5).

Values of Ca and P before heat exposure were non significant change at 25 d. old in all groups (Table, 6). After heat exposure, Ca level showed

insignificant decrease in 2nd gp. compared with 1st gp. Addition of electrolyte solution resulted in a significant increase in Ca level in gp. 5 (within normal limit) compared with gps. 2, 3 and 4. Regarding to P level, 2nd gp. showed insignificant increase after heat exposure, while addition of electrolyte solution led to a high significant increase in P level with all concentrations (Table, 6).

Values of K, Ca and P before heat exposure were non significant change at 35 d. old in all groups (Table , 7) . After heat exposure, regarding to potassium level gps. 3 and 4 showed slight increase in K level than other groups. Ca level increased significantly (within normal limit) in gp. 5 compared with other groups. P level increased significantly (within normal limit) in gp. 4 compared with other groups (Table, 7).

Experiment II : Effect of heat and electrolyte solution at 41-43d. old chickens during chronic HS exposure:

The effect of heat exposure (gp. 2) on water and feed consumption is shown in Table (4). Water consumption increased by 8.68%, while feed consumption decreased by 4.73% compared with 1st gp. Addition of electrolyte solution led to increase water and feed consumption, the highest ratios were 37.74% and 35.14%; respectively (gp.5) compared with 1st gp.

Regarding mortality rate, the effect of heat exposure (gp. 2) recorded the highest mortality rate by the ratio of 23.33% compared with 1st gp., while gp. 5 showed no mortalities (Table, 4). The effect of heat exposure (gp.2) on body weight at six weeks old was non significant change compared with 1st gp. (Table, 5). Addition of electrolyte solution led to a significant increase in BW in 3rd and 5th gps. . The highest ratio was 6.45% in gp.5 compared with 1st gp.

Values of K, Ca and P before heat exposure showed non significant change (Table, 8). After heat exposure, gp. 5 showed a significant increase in K level. Regarding to Ca level, the effect of heat exposure (gp.2) was non significant decrease in Ca level compared with 1st gp. . Addition of electrolyte solution led to a significant increase in Ca level in groups 3 and 5 (within normal limit) compared with other groups. Regarding to P level, the effect of heat exposure (gp.2) led to a non significant increase in P level. Addition of electrolyte solution led to a significant increase in P level (within normal limit) with all concentrations (Table, 8).

DISCUSSION

When chickens exposed to acute heat stress, the decrease in feed intake led to a non significant decrease in body weight at 4 th week and a significant decrease at 5 th week. While chronic heat exposure led to adaptation of chickens to heat and no change in body weight due to the decrease in feed intake was minimum. Also, high thermal exposure of chickens resulted in body weight loss mainly consisting of water loss (dehydration). The same results previously obtained by Vander Hel et al., (1991), May and Lott (1992), Waibel and Macleod (1992) and Eberhart and Washburn (1993).

Supplementation of drinking water with electrolyte solution in different concentrations significantly increased body weight compared with 1st & 2 nd groups due to the increase in water and feed consumption in groups administered electrolyte solution. Austic (1979) mentioned that potassium was known to stimulate water consumption. Also, Teeter (1988) mentioned that growth improvement of poultry at high temperature occurred when electrolytes containing potassium and sodium chloride were added to the drinking water. Beker and Teeter (1993) mentioned that water supplemented with KCl led to increase feed consumption and body weight gain.

The increase in water consumption with a decrease in feed consumption when chickens exposed to high temperature to compensate the dehydration which occurred. Similar results previously obtained by Squibb et al., (1959), Mccormick et al., (1979), Teeter et al., (1985), North and Bell (1990), Ferket and Qureshi (1992), Han and Baker (1992), May and Lott (1992), Van Der Hel et al., (1992) and Yalcin et al., (1997). Also, survival of chickens during heat stress was dependent upon water consumption (FOX, 1951).

Supplementation of drinking water with electrolyte solution during heat exposure led to broilers consume more water. Similar result previously obtained by Sands and Smith (1996), mentioned that broilers receiving electrolytes (KCl or NaCl) in the drinking water during heat stress consumed more water than controls receiving no water additive as K is known to stimulate water consumption (Austic, 1979).

Increase mortality rate due to heat stress previously mentioned by Reece et al., (1972) and Eberhart and Washburn (1993).

Supplementation of drinking water with electrolyte solution reduced mortality rate especially when used 2.00 ml/liter distilled water due to electrolyte solution improve water and feed consumption. The same result previously obtained by Branton et al., (1986) and Smith and Teeter (1989).

Regarding electrolyte status, the increase in potassium level after supplementation of drinking water with electrolyte (*Almaril Plus)* as it contains potassium (1.4%) . Smith and Teeter (1987) mentioned that dietary K level of 1.5% for broiler chickens was needed to prevent K imbalance under conditions of chronic heat stress.

The insignificant decrease in calcium after acute and chronic heat exposure previously mentioned by Ait-Boulahsen et al., (1989) and Belay and Teeter (1996). They noticed hypoalbuminemia and hypocalcemia in broilers exposed to high temperature. Also, Meluzzi et al., (1992) noticed hypoalbuminemia and hypocalcemia with high summer temperature. Hypocalcemia may also be due to increase fecal calcium in heat stressed hens as mentioned by Mahmous et al., (1994).

Addition of electrolyte solution to drinking water improved the result. The best result obtained in 5th group.

The non significant hyperphosphatemia after heat exposure may be due to the non significant hypocalcemia which occurred, as the metabolism of calcium and phosphorus was closely linked in the body and hypocalcemia was always accompanied by hyperphosphatemia. The same result previously obtained by Meluzzi et al., (1992) , they observed hyperphosphatemia with high summer temperature.

Supplementation of drinking water with electrolyte solution led to a significant increase in P level in most groups due to that *Almaril Plus* contains phosphorus (1.2%).

CONCLUSION

Acute and chronic heat stress caused undesirable changes in broilers. The present study demonstrated that electrolyte solution supplementation to the drinking water used to enhance the tolerance of chickens to heat stress. Using 2.00 ml *Almaril Plus*/liter water produced favorable changes especially at six weeks age (exp. II) (marketing age) regarding mortality rate, body weight and serum potassium and calcium levels .

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Table (2): Effect of heat and electrolyte solution on water & feed consumption and mortality rate at 25 d. old chickens during acute HS exposure.

Variable / Groups	Water consumption per ml	Feed consumption per gram	Mortality rate	
			Number	%
1 (- ve control)	200	87.5	zero	zero
2 (+ ve control)	233	75	zero	zero
3 (0.625 ml)	255	129	zero	zero
4 (1.25 ml)	208	154	zero	zero
5 (2.00 ml)	263	133	zero	zero

Table (3): Effect of heat and electrolyte solution on water & feed consumption and mortality rate at 35 d. old chickens during acute HS exposure.

Variable / Groups	Water consumption per ml	Feed consumption per gram	Mortality rate	
			Number	%
1 (- ve control)	240	140	zero	zero
2 (+ ve control)	249	128	5	16.67
3 (0.625 ml)	259	186	5	16.67
4 (1.25 ml)	344	250	5	16.67
5 (2.00 ml)	271	219	2	6.67

Table (4): Effect of heat and electrolyte solution on water & feed consumption and mortality rate at 41-43 d. old chickens during chronic HS exposure.

Variable / Groups	Water consumption per ml	Feed consumption per gram	Mortality rate	
			Number	%
1 (- ve control)	265	148	zero	zero
2 (+ ve control}	288	141	7	23.33
3 (0.625 ml)	301	157	3	10
4 (1.25 ml)	345	163	1	3.33
5 (2.00 ml)	365	200	zero	zero

Table (5): Effect of heat and electrolyte solution on body weight (gm) during acute and chronic HS exposure.

Age Groups	Three weeks	Four weeks	Five weeks	Six weeks
1(-ve control)	440.5±9.8	759.0±15.7 **b**	1377.0 ±23.5 **a**	1612.0±30.1 **c**
2(+ve control)	422.0±11.3	747.5±32.5 **b**	1358.0± 32.9 **b**	1616.0± 39.4 **c**
3 (0.625 ml)	420.5±7.1	827.5±29.7 **a**	1413.5±37.6 **a**	1679.0±30.9 **b**
4 (1.25ml)	453.0± 11.0	805.0±28.5 **a**	1383.5±34.7 **a**	1618.0±36.9 **c**
5 (2.00 ml)	445.0±11.5	811.0±35.3 **a**	1375.0±36.4 **a**	1716.0±30.7 **a**
F- test	N.S	*	*	*
L.S.D.	--	35.30	45.50	33.40

L.S.D. : Least significant difference.

N.S.: Non significant. *** : Significant at 0.05 probability.**

Table (6): Effect of heat and electrolyte solution on k, Ca and P at 25 d. old chickens during acute HS exposure.

Variable	Treated	Groups					F-test	L.S.D.
		1(-ve control)	2(+ve control)	3 (0.625 ml)	4 (1.25 ml)	5 (2.00 ml)		
K	B	Not recorded						
mEq/L	A							
	Δ							
Ca	B	14.58±1.33	14.31±1.39	14.76±1.22	15.31±1.30	14.97±1.20	N.S	---
mg/ dl	A	9.18±0.73 ab	7.25±1.00 b	8.58±0.78 b	8.82±0.80 b	12.05±0.87 a	*	2.90
	Δ	- 5.4	-7.06	- 6.18	-6.49	-2.92		
P	B	4.63±1.76	5.65±1.37	5.37±1.51	6.65±0.99	5.66±1.21	N.S	----
mg/ dl	A	5.10±0.41 b	6.28±1.96 b	12.84±1.28 a	10.71±0.98 a	11.26±1.28 a	**	2.73
	Δ	+ 0.47	+0.63	+7.47	+4.06	+5.60		

B= Value before heat exposure.
A= Value after heat exposure.
Δ= Heat enhanced change (A-B).
L.S.D.= Least significant difference.
N.S= Non significant.
*** = Significant at 0.05 probability.**
**** = Significant at 0.01 probability.**

Table (7): Effect of heat and electrolyte solution on k, Ca and P at 35 d. old chickens during acute HS exposure.

Variable	Treated	Groups					F- test	L.S.D.
		1(-ve control)	2(+ve control)	3 (0.625 ml)	4 (1.25 ml)	5 (2.00 ml)		
K	B	6.22± 0.30	5.79±0.47	4.53±0.45	4.67±0.57	5.58±0.69	N.S	--
mEq/L	A	5.88±0.43	5.29±0.35	6.45±0.50	6.48±0.57	6.01±0.44	N.S	--
	Δ	- 0.34	-0.50	+1.92	+1.81	+0.43		
Ca	B	11.34±1.06	11.66±1.20	12.54±1.09	12.97±1.11	10.37±1.00	N.S	--
mg/ dl	A	7.73±1.20 b	7.38±1.33 b	8.32±1.37 b	8.12±1.30 b	12.43±1.20 a	*	4.00
	Δ	- 3.61	- 4.28	- 4.22	- 4.85	+2.06		
P	B	7.68±0.74	7.02±0.59	6.87±0.59	7.54±0.76	7.35±0.71	N.S	--
mg/ dl	A	8.04±0.89 b	7.08±0.95 b	7.76±0.65 b	9.97±0.90 a	7.07±0.73 b	*	1.90
	Δ	+0.36	+0.06	+0.89	+2.43	-0.28		

B= Value before heat exposure. **A= Value after heat exposure.**

Δ= Heat enhanced change (A-B). **L.S.D.= Least significant difference.**

N.S = Non significant. *** = Significant at 0.05 probability.**

Table (8): Effect of heat and electrolyte solution on k, Ca and P at 41-43 d. old chickens during chronic HS exposure.

Variable	Treated	Groups					F- test	L.S.D.
		1(-ve control)	2(+ve control)	3 (0.625 ml)	4 (1.25 ml)	5 (2.00 ml)		
K	B	3.89± 0.38	3.41±0.36	3.05± 0. 26	3.59±0.48	3.11±0.31	N.S	---
mEq/L	A	5.60±0.58 b	4.88±0.62 b	5.97±0.97 b	5.89± 0.64 b	7.68±0.94 a	*	1.60
	Δ	+1.71	+1.47	+ 2.92	+ 2.30	+4.57		
Ca	B	14.08±1.01	13.25±1.02	12.31±0.71	12.31±0.92	12.96±0.95	N.S	--
mg/ dl	A	9.59±0.74 bc	8.13±0.75 c	14.55±1.03 a	11.74±1.04 ab	12.93±1.11 a	*	2.80
	Δ	-4.49	-5.12	+ 2.24	- 0.57	- 0.03		
P	B	5.31±0.65	4.35±0.90	4.41±0.43	4.91±0.71	4.82±0.74	N.S	--
mg/ dl	A	5.06±0.48 b	6.00±0.54 b	7.53±0.52 a	7.26±0.58 a	7.40±0.46 a	*	1.20
	Δ	- 0.25	+ 1.65	+ 3.12	+ 2.35	+ 2.58		

B= Value before heat exposure.
A= Value after heat exposure.
Δ= Heat enhanced change (A-B).
L.S.D.= Least significant difference.
N.S= Non significant.
* = Significant at 0.05 probability.