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The Effect of Early Age Heat Conditioning and Some Feeding Programs for Heat-Stressed Broiler Chicks On: 1 - Productive Performance

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Abstract: The beneficial effect of raising ambient temperature at early age, some feeding programs and their combination in improving productivity of broiler chicks under summer season stress conditions was examined. A total of 144 one -day -old commercial broiler chicks were used in the present study. They were divided into two groups of 72 birds each. The first group was subjected to 38°C ±1° for 24hrs at day5 post-hatching (heat conditioning group, H.C) while the second group was kept as a control (non heat conditioning group, N.H.C). At day7 birds were individually weighed, wing banded and then divided into four sub groups with approximately similar initial body weight. The sub groups were1- qualitative (70%) feed restriction (F.R) on days 7, 8 and 9 post-hatching, 2- feed withdrawal (F.W.D) for 24hrs on day 9, 3- supplemental vitamin C (Vit. C) from 21 to 42 day of age and then 4-the control group**.** Results indicate that average body weight, weight gain, feed intake and feed conversion ratio were significantly affected at 42 days old. It is concluded from the present results that subjecting broiler chicks to early age heat conditioning at 5days old or using some feeding programs (F.R, F.W.D and Vit. C) during hot environmental temperatures could improve the productivity of broiler chicks under summer stress conditions.

Key words: Broiler chicks · Heat stress · Feed restriction · Vitamin C · Heat conditioning

INTRODUCTION

High ambient temperature as encountered in Egypt and many other countries during summer season can generate a state of stress and evokes a combination of behavioral, biochimical and physiological changes. This generally resulted in a reduction in broiler chicks performance. The major effects of heat stress decreased feed intake (FI), growth rate, feed efficiency, lower weight gain and increased fat deposition [1-3]. One of the practical approaches that have yielded promising results is altering bird's abilities to cope with high ambient temperatures through stimulation early in life. There is evidence that stressful experiences during the neonatal stage can have considerable impact on various facets of an animal's physiology and behavior. Exposure of 5-day-old broiler chicks to elevated temperature improved survivability in otherwise lethal heat treatment at 42 days of age [4, 5]. This is based on the fact that full-blown homoeothermic starts at approximately 10days post-hatch. For increasing the thermo- tolerance capacity of the birds and also inhibition of economic losses as a result of heat stress, two management models has been suggested, heat shock and adaptation of birds to desired environmental conditions [6]. These methods have provided some suitable results for broiler industry. The fast response of heat shock can be achieved by application of this technique at early growth phase [4, 7]. This technique benefits from the immature temperature-regulating system in broiler chicks at early age [8].

Several studies revealed that heat-stressed broiler chicks gained more body weight when supplemented with Vitamin C [9-11]. Addition of Vitamin C to poultry diets was reported to improve feed conversion ratio and enhancing nutrients utilization [12, 13]. Furthermore, as Vitamin C is one of the most important antioxidants in biological system and heat stress could induce oxidative injuries to chicks [14], the supplementation of Vitamin C is relevant to the maintenance of redox balance in heat-stressed birds.

Feed restriction at an early age has been demonstrated to have a beneficial effect on alleviating the subsequent responses to heat stress [15, 16].

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Chicks subjected to 60% feed restriction at 4, 5 and 6 days of age have improved growth and survivability in response to the subsequent heat treatment at marketing age (from 35 to 41 days). Early feed restriction (F.R) could work in concert with early heat condition (EHC) treatment. Improved heat tolerance and disease resistance are observed in chicks suffering FR together with EHC "60% feed restriction on days 4, 5 and 6 of exposure to 36°C for 1 hr. from 1 to 21days" [17]. Therefore, the objectives of the present study were to evaluate the effect of different approaches (early age heat conditioning, manipulation of diet composition, feed deprivation, Vit.C supplementation) on productive performance traits in broiler chicks under summer stress conditions.

MATERIALS AND METHODS

The present experiment was carried out under hot climates of summer season in Egypt, where the maximum environmental temperature ranged from 32-37°C during the experimental period. A total of 200 one -day -old unsexed commercial broiler chicks " Hubbard "were obtained from a local hatchery. Upon arrival the chicks were divided into two groups of 100 birds. At 5-days of age the first group was exposed to 38±1°C for 24h (heat conditioning, " HC'') while the second group was exposed to the normal brooding (32±1°C) temperature (Non heat conditioning, " N.H.C ‘‘).At 7 days of age, birds were individually weighed to the nearest gram then a total of 72 chicks from each group were selected and wing banded. The selected birds were divided into four sub-groups, 18 chicks each, in such a way that the mean weight of all sub-groups were approximately similar. The birds were distributed singly in separate cages. They were assigned at random to receive one of the fourth experimental treatments, which were control group**,** Feed withdrawal (F.W.D) on days 9 for 24hrs, Qualitative feed restriction (70%) on days7, 8 and 9 (F.R) and Vitamin C 20% (Vit.C) was added to the diet (1g/Kg diet "200ppm" replaced by a similar amount of limestone in the diet at 21 to 42 days. Water and feed offered *ad libitum* -except for the F.W.D group at day 9- and artificial light was provided (22 hrs) daily all over the experimental period, which lasted for 6 weeks. Chicks of all treatment sub-groups were kept under similar hygienic and environmental conditions. The experimental diets either starter (0-21days) or grower (21-42days) was formulated according to recommended requirements of "Hubbard "strain used. The composition and calculated analysis of the experimental diets are shown in Table 1.

Table 1: Composition and calculated analysis of the experimental diets

	Starter (%) (0-21days)		
	----------		Grower
Ingredient	Control	Feed restriction	(%)(21-42days)
Yellow corn	55.600	36.680	62.750
Soybean meal (44%)	28.700	14.000	21.450
Corn gluten meal (62%)	8.950	--	8.950
Di-Ca phosphate	2.185	2.00	2.080
Soy oil	2.300	--	2.500
Sodium Bicarbonate	0.200	0.200	0.200
Limestone	1.035	1.240	0.920
Methionine	0.175	0.160	0.180
Lysine	0.295	0.140	0.420
Vit.min.mixture*	0.300	0.300	0.300
Wheat bran	--	45.100	--
Salt	0.260	0.180	0.250
Total	100	100	100
Calculated analysis**			
Crude protein %	23.00	16.08	20.51
ME kcal/kg	3052	2138	3152
Crude fiber %	3.50	6.75	3.13
Methionine+ Cystine %	0.97	0.72	0.93
Lysine %	1.30	0.89	1.2
Calcium %	1.03	1.05	0.94
Av.Phosphorus %	0.50	0.52	0.47
Na	0.18	0.18	0.18

*: Vitamin and mineral mixture: each kilogram of diet contains: Vit. A, 12000 I.U., Vit.D3, 2500 I.U., Vit. E, 10 mg, Vit.B1, 2 mg, Vit.B2, 5 mg, Vit.B6, 4 mg, Vit. B12, 10 µg, Niacin, 25 mg, Pantothenic acid, 10 mg, Biotin, 50 µg, Folic acid, 1000 µg., Vit.K, 2.0 mg and Choline chloride, 255 mg, Selenium, 300 µg, Copper, 10 mg, Iodine, 1.0 mg, Iron, 33 mg, Manganese, 60 mg and 60 mg. Zinc.

** According to National Research Council (NRC) [20]

Data on body weight (BW), feed intake(FI) were individually recorded at the end of each period (21 and 42 days of age) and then the feed conversion ratio (FCR) was calculated as gram feed to gram body weight gain (BWG). At the end of the experimental period, three birds from each treatment group were randomly taken, weighed and slaughtered. The carcass with neck, abdominal fat (A.F), liver, heart, gizzard, thigh and breast meat yield were separately and expressed as percentage of live body weight. The economic efficiency values were calculated according to the prevailing market prices for feed ingredients as well as the price of one kilogram live body weight at the end of experimental period which was 10.50 L.E. (Egyptian Pound). Data were subjected to the analysis of variance by using the General Linear Models procedure (GLM) of the Statistical Analysis System [18]. Differences among treatment means were detected by using Duncan’s multiple range test [19].

RESULTS AND DISCUSSION

Effect of different treatments on BW and BWG of broilers chicks is illustrated in Table 2. It appeared that chicks of all treatments had a similar growth performance until the end of the starting period (21 day of age).When the environmental temperature (30°C and above) exceeds the brooding temperature requirements (24°C) during the growing period (from 21 to 42 days of age), Significant treatment differences (P<0.05) in favor of early age "HC," was recorded for both final BW and BWG at 42 days compared with the "NHC "group. Also, early age heat conditioning group has significantly (p<0.05) higher BWG during the period from 21 to 42 days compared with the" NHC "group. Concerning feeding programs, the present data show that there were insignificant effects(P<0.05) of these programs on BW and BWG at 21 days, however, their effect was significantly on BWG at the period from 21 to 42days or all over the experimental period where the best BW and BWG values were recorded for Vit.C supplemented group. However, it was not significantly differed (P<0.05) for feed withdrawal (FWD) and feed restriction (FR) groups compared with the control group. Also, there were no significant differences (P<0.05) between Vit.C group and both F.R and F.W.D groups. These data show that BW at 42 days was significantly influenced by both feeding programs and heat conditioning and their interaction. This reflects the capability of birds to compensate for growth retardation (associated with heat stress) by different means including physiological and endocrinological mechanisms. It may be that the hypothalamic set point of body temperature was changed by increasing the threshold core-temperature for heat production and/or heat loss, since the potential of thermo tolerance can thus be improved. The growth stimulation which was recorded for Vit.C supplemented group may reflect the beneficial effect of this vitamin on growth performance. It is suggested that supplemental Vit.C could improve heat tolerance and alleviate body weight reduction associated with stress conditions. These findings are in agreement with those reported by Kutlu and Forbes [9] and Hahn *et al*. [11] who observed an improvement in growth performance of broiler chicks reared in the tropic environment when their diet was supplemented with Vit.C, this improvements in growth may be attributed either to the partial correction in

Table 2: Effect of different treatments on body weight (BW) and body weight gain (BWG) of broiler chicks at different ages

Trait	Body weight (BW) (g)			Body weight gain (BWG) (g)		
Treatment	1 day	21 day	42 day	1-21 day	21-42 day	1-42 day
Non heat conditioning						
Control	43.88	478.11	1625.27^{c}	434.22	1135.47^{c}	1581.07 ^{c}
F.W.D	42.88	473.61	1670.27^{bc}	430.72	1191.53^{bc}	1627.73^{bc}
F.R	43.66	492.50	1705.13^{bc}	448.83	1216.13^{bc}	1661.87^{bc}
Vitamin C	43.33	468.06	1711.07^{bc}	424.72	1245.27^{abc}	1667.87^{bc}
Heat conditioning						
Control	42.77	496.67	1752.47^{abc}	453.89	1251.00^{abc}	1708.67^{abc}
F.W.D	43.16	462.94	1767.47^{abc}	419.78	1307.60^{ab}	1724.47^{abc}
F.R	43.88	465.89	1792.93^{ab}	422.00	1316.13^{ab}	1749.13^{ab}
Vitamin C	42.94	499.11	1885.00^{a}	456.17	1377.93^{a}	1841.40^{a}
SEM	0.93	14.79	47.75	14.68	42.81	47.80
Overall of feeding						
Control	43.33	487.39	1688.87^{b}	444.06	1193.23^{b}	1644.87^{b}
F.W.D	43.03	468.28	1718.87^{ab}	425.25	1249.57^{ab}	1676.10^{ab}
F.R	43.78	479.19	1749.03^{ab}	435.42	1266.13^{ab}	1705.50^{ab}
Vitamin C	43.14	483.58	1798.03^{a}	440.44	1311.60^{a}	1754.63^{a}
SEM	0.65	10.46	33.76	10.38	30.47	33.80
Overall of heat						
Non heat	43.44	478.07	1677.93^{b}	434.63	1197.10^{b}	1634.63^{b}
Heat	43.19	481.15	1799.47^{a}	437.96	1313.17^{a}	1755.92^{a}
SEM	0.46	7.39	23.87	7.34	21.40	23.90
Source of variation						
Feed	NS	NS	*	NS	*	*
Heat	NS	NS	*	NS	*	*
Feed x Heat	NS	NS	*	NS	*	*

a, b and c Means within a column and section with no common superscript differ significantly (P<0.05).

NS= Not-significant

SEM=Standard error of means

Table 3: Effect of different treatments on Feed intake (FI) and Feed conversion ratio (FCR) of broiler chicks at different ages

Trait	Feed intake (g)			Feed conversion ratio		
Treatment	1 day	21 day	42 day	1-21 day	21-42 day	1-42 day
Non heat conditioning						
Control	851.94	2213.93^{c}	3071.27^{cd}	1.79	1.96^{a}	1.89^{a}
F.W.D	830.00	2224.13^{c}	3052.47^{cd}	1.75	1.88^{abc}	1.83^{abc}
F.R	831.39	2256.27^{bc}	3098.67^{cd}	1.69	1.87^{abc}	1.82^{abc}
Vitamin C	819.83	2189.07^{c}	3000.73^{d}	1.75	1.77^{bc}	1.76^{bc}
Heat conditioning						
Control	887.39	2370.27^{ab}	3262.67ab	1.79	1.91^{ab}	1.86^{ab}
F.W.D	823.00	2345.93^{ab}	3187.53abc	1.79	1.81^{bc}	1.81^{abc}
F.R	823.78	2295.20^{abc}	3134.00b^{cd}	1.78	1.76^{c}	1.76^{bc}
Vitamin C	898.78	2385.20^{a}	3289.60^{a}	1.80	1.75^{c}	1.76^{bc}
SEM	2.01	37.97	50.38	0.05	0.05	0.04
Overall of feeding						
Control	869.67	2292.10	3166.97	1.79	1.94^{a}	1.88^{a}
F.W.D	826.50	2285.03	3120.00	1.77	1.84^{b}	1.83^{ab}
F.R	827.58	2275.73	3116.00	1.73	1.82^{b}	1.79^{b}
Vitamin C	859.31	2287.13	3145.17	1.77	1.77^{b}	1.76^{b}
SEM	17.68	26.85	35.63	0.03	0.03	0.03
Overall of heat						
Non heat	833.29	2220.85^{b}	3055.78^{b}	3055.78^{b}	1.74	1.83
Heat	858.24	2349.15^{a}	3218.45^{a}	3218.45^{a}	1.79	1.80
SEM	12.505	18.98	25.19	0.02	0.02	0.02
Source of variation						
Feed	NS	NS	NS	NS	*	*
Heat	NS	*	*	NS	NS	NS
Feed x Heat	*	*	*	NS	*	*

a, b and c Means within a column and section with no common superscript differ significantly (P<0.05).

NS= Not-significant

SEM=Standard error of means.

acid-base balance or to the increase in water intake which act as a heat sink. Thus, it appears that subjecting birds at early age to F.R or F.W.D programs may alleviate the detrimental influence of high ambient temperature on growth. Previous studies by Zulkifli *et al*. [15, 16] and Liew *et al*. [17] confirmed the present results. They concluded that subjecting broiler chicks to 60% feed restriction at 4, 5 and 6 days of age have improved growth and survivability in response to the heat stress from 35 to 41 days as compared with the *ad libitum* feeding chicks.

The effect of different treatments on feed intake (FI) and feed conversion ratio (FCR) is presented in Table 3. It is generally observed that (FI) was significantly (P<0.05) increased in the heat conditioning groups than non-heat treated ones at periods from 21 - 42 and 1 -42days of age. However, heat exposure did not affect (FI) at 1 -21 days. The effect of feeding programs on (FI) was not-significant at different growing periods. On the other hand, feeding programs have significant effects on (FCR) at periods from 21 - 42 and for the whole period 1-42 days of age. The best (FCR) was recorded for Vit.C supplemented group. There were insignificant effects (P<0.05) of early age heat conditioning on (FCR) during all growth periods. However, the interaction between early heat conditioning and feeding programs was significantly different (P< 0.05) for the studied periods. Feed intake values were higher in Vit.C supplemented diets of early"HC" at 21-42 and 1-42 days of age. A similar trend was also observed for the values of (FCR) which was improved significantly (p<0.05) for both Vit.C supplemented and F.R groups under heat conditioning at 21-42 and 1-42 days of age. It is hypothesized that early age stressors (heat, malnutrition, disease, vaccination…. etc) are associated with some responses including growth retardation followed by long term compensatory growth which resulted in higher LBW coincided with higher FI and improvement in FCR. These results are in close agreement with those reported by Yahav and Hurwitz [4], Zulkifli *et al*. [21] and Sahin *et al.* [22]. The supplementation of Vit.C when birds are challenged with stressors might be beneficial for the performance of broilers [23].

Table 4: Relative weights of carcass and some organs of broiler chicks at 42 days of age

Trait Treatment	Carcass (%)	A.F (%)	Heart (%)	Gizzard (%)	Liver (%)	Thigh (%)	Breast (%)
Non heat conditioning							
Control	73.80	1.78	0.38	1.53	1.78^{ab}	15.08	19.39
F.W.D	74.83	1.78	0.39	1.54	1.83^{a}	14.91	20.07
F.R	73.23	1.77	0.37	1.53	1.65^{abc}	14.96	19.29
Vitamin C	74.47	1.84	0.35	1.54	1.79^{ab}	14.95	19.19
Heat conditioning							
Control	74.27	1.86	0.35	1.51	1.66^{abc}	15.44	20.04
F.W.D	74.33	1.79	0.36	1.48	1.51^{c}	15.45	20.16
F.R	74.54	1.82	0.36	1.47	1.50^{c}	15.31	19.22
Vitamin C	73.41	1.81	0.37	1.54	1.55^{c}	15.18	19.10
SEM	0.88	0.06	0.01	0.05	0.08	0.31	0.56
Overall of feeding							
Control	74.07	1.82	0.37	1.52	1.73	15.26	19.71
F.W.D	74.56	1.79	0.37	1.51	1.67	15.18	20.12
F.R	73.32	1.79	0.37	1.50	1.58	15.14	19.25
Vitamin C	74.50	1.83	0.36	1.54	1.67	15.07	19.15
SEM	0.62	0.04	0.01	0.03	0.06	0.22	0.40
Overall of heat							
Non heat	73.08	1.79	0.37	1.53	1.76^{a}	14.98	19.48
Heat	74.13	1.82	0.36	1.50	1.56b	15.35	19.63
SEM	0.44	0.03	0.01	0.02	0.04	0.15	0.28
Source of variation							
Feed	NS	NS	NS	NS	NS	NS	NS
Heat	NS	NS	NS	NS	*	NS	NS
Feed x Heat	NS	NS	NS	NS	*	NS	NS

a, b and c Means within a column and section with no common superscript differ significantly (P<0.05).

NS= Not-significant

SEM=Standard error of means.

A.F =^{ab}dominal fat.

It can be observed from this study, that early age heat conditioning of broiler chicks and feeding programs (F.R, F.W.D and Vit.C supplementation) may be considered as a suitable means to overcome the depressing effect of heat stress. The early heat conditioning alone or combined with either Vit.C or early feed restriction would be preferable for chicks kept at hot conditions, with respect to growth performance.

The overall means of carcass weight (%) and the proportional weights of some body organs are presented in Table 4. Broiler chicks receiving different dietary treatments showed insignificant responses for all the studied traits, except the liver weight (%). The relative weights of liver were significantly (P< 0.05) different between the early age heat conditioning groups and non-heat conditioning one. The values obtained were 1.764 and 1.557% for the "NHC" and "HC", respectively. Regardless, heat conditioning treatment, feeding programs showed no significant effects on all studied parameters, although some slight changes in the relative weights of abdominal fat, liver and breast were observed. These results may support the previous findings that birds are able to compensate the retardation of growth by different magnitudes including the well documented relationships between the dietary supplements and some endocrine functions which include the stimulatory effects of Vit.C on thyroid gland activity under heat stress conditions. It is well known that the normal growth of all body organs needs a euthyroid status [3] which adversely affected by increasing ambient air temperature [2]. Since, the supplemental Vit.C is of great importance to compensate or modulate the growth depression that could be expected under hot conditions.

The total cost of feed consumption and the total income as well as economic efficiency values of the product for different experimental treatments are shown in Table (5). The economic efficiency values were calculated according to the prevailing market prices for feed ingredients as well as the price of one kilogram live body weight at the end of experimental period which was 10.5 L.E. The results showed that, there is considerable saving in feed cost/Kg live body weight in early heat conditioning group either alone or combined with some feeding programs. The highest feed cost/Kg LBW was for control treatments in both non heat conditioning and heat conditioning groups (4.56 and 4.51 L.E, respectively).

Table 5: Effect of different treatments on economical efficiency, at the end of the experimental period

Treatment	Non heat conditioning				Heat conditioning			
Item	Cont.	F.W.D	F.R	Vit C	Cont.	F.W.D	F.R	Vit C
Feed intake (Kg / bird)								
Starter	0.85	0.83	0.74	0.82	0.89	0.82	0.73	0.90
F.R	--	--	0.09	--	--	--	0.09	--
Grower	2.21	2.22	2.26	2.19	2.37	2.35	2.26	2.39
Body weight (Kg / bird)	1.63	1.67	1.70	1.71	1.75	1.77	1.79	1.89
Feed cost / bird (L.E)								
Starter	2.47	2.47	2.47	2.47	2.47	2.47	2.47	2.47
F.R	--	--	1.67	--	--	--	1.67	--
Grower	2.41	2.41	2.41	2.43	2.41	2.41	2.41	2.43
Feed price (L.E / Kg)								
Starter	2.10	2.05	1.83	2.03	2.19	2.03	1.81	2.22
F.R	--	--	0.15	--	--	-	0.15	-
Grower	5.33	5.36	5.43	5.31	5.71	5.65	5.53	5.79
Total Feed cost / bird (L.E)	7.43	7.41	7.41	7.34	7.90	7.68	7.49	8.01
Total Feed cost / Kg BW (L.E)	4.56	4.44	4.36	4.29	4.51	4.34	4.18	4.24
1Fixed costs (L.E)	3.50	3.50	3.50	3.50	3.55	3.55	3.55	3.55
Total costs (L.E / bird)	10.93	10.91	10.91	10.74	11.45	11.23	11.04	11.56
2Total income (L.E / bird)	17.10	17.5	17.9	18.0	18.4	18.6	18.8	19.9
3Net revenue (L.E / bird)	6.18	6.62	6.94	7.22	6.95	7.36	7.76	8.29
4Economic efficiency	0.57	0.61	0.64	0.67	0.61	0.66	0.70	0.72
5Relative economic efficiency %	100	107.0	112.3	117.5	107.0	115.8	122.8	126.3

1- Bird price and rearing costs.
2- Body weight× price per one Kg (10.50 L.E).
3- Total income - Total costs.
4- Net revenue per unit of total costs.
5- Relative to the economic efficiency of the control.

It is interested to note that, all feeding programs regardless early heat conditioning recorded higher total income (L.E/bird) and net revenue (L.E/bird). Vit.C supplementation and FR groups achieved the best total income (L.E/bird) and net revenue (L.E/bird), respectively. These results are due mainly to improvement in feed conversion ratio and body weight of these groups. On the other hand," HC" groups recorded higher total income and net revenue than "NHC"groups. The same trend was observed for the percentage of economic efficiency relative to the total cost. Thus, the economic evaluation provided further evidence for the benefits of using early heat conditioning either alone or combined with some feeding programs as an attempt to alleviate the influences of heat stress (during growing period) on broiler chicks.

It is concluded from the present results that subjecting broiler chicks to early age" HC" at 5 days of age or using some feeding programs (F.R, F.W.D and Vit. C) during hot environmental temperatures could improve the productivity of broiler chicks under summer stress conditions.

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