Nutritional Strategies to Combat the Effect of Heat Stress in Chicken

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Abstract

Heat stress reduces the production performance of chicken leads to immunosuppression and increases the mortality rate in chicken. All the nutritional supplements (e.g. vitamins, zinc, Kcl) have functions in relation to heat stress. Suitable mineral and vitamin premixes can be developed for heat stressed chickens for improved performance, welfare and reducing feed cost. Heat stress increase the serum concentration of ACTH which increase corticosteroid level and in turns reduces the production. Dietary supplementation of vitamin C (200 mg/kg) improved the egg production and egg shell quality in laying hen during summer stress. Ascorbic Acid supplementation (300 mg/kg of diet) improved body weight gain, feed conversion ratio and decreased the mortality in broilers. Dietary supplementation of anti-oxidant vitamins (vitamin E or vitamin C in combination) is helpful to maintain the growth performance, egg production and improvement in egg quality. Vitamin E (250 mg/kg diet) increased serum concentration of T_3, T_4 and decreased concentration of ACTH thereby production is maintained. Low protein diet (14%) with provision of additional methionine @ 0.44% maintained the production performance of laying hens. Supplementation of Dietary Electrolyte Balance like NaCl, $NaHCO_3$, $KHCO_3$ and NH_4Cl (360 m Eq/kg) in heat stress can improve eggshell quality of laying hens. Supplementation of 0.1% KCl with 400 mg vitamin C showed better performance for broilers reared under heat stress. Zinc in combination with vitamin A improves performance and carcass quality of broiler under heat stress.

Keywords: Immunosuppression; Acth; Electrolyte; Vitamin C; Vitamin E; Stress; KCl; Vitamin A.

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Introduction

Stress

The term stress is described as, "a physical or psychological stimulus that can produce mental tension or physiological reactions that may lead to illness."

Or

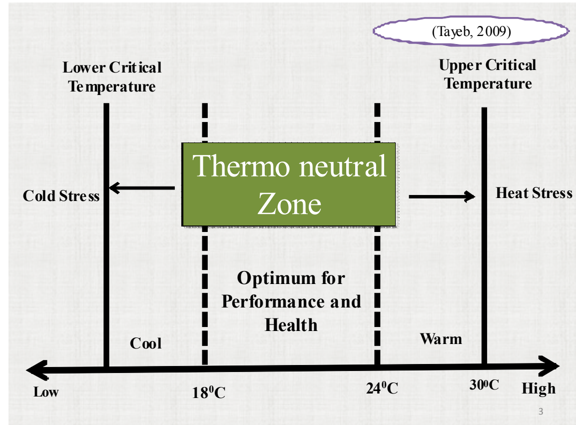
Deviation from Normal Physiological behaviour.

Or

The term "Stress" is used to describe the detrimental effects of variety of factors on the health and performance of poultry. Birds have limited body resources for growth, reproduction, response to environmental changes and defense mechanism.

Factor affecting stress

1. *Environmental:* Poor Ventilation, ammonia gas, Pollutants, wet liter, high light intensity
2. *Climatic:* Extreme heat / cold, humidity
3. *Physical:* Catching, Handling Transport, Injections, Ion mobilization etc.
4. *Nutritional:* Nutrient Shortages, Feed intake Problems, Adulterated feed, Toxic
5. *Physiological:* Rapid growth, high egg prod., Process of sexual Maturing, Molt-ing etc.
6. *Social:* Over crowding various age/size, Grouping
7. *Psychological:* Fear, harsh care takers, abrupt changes etc.



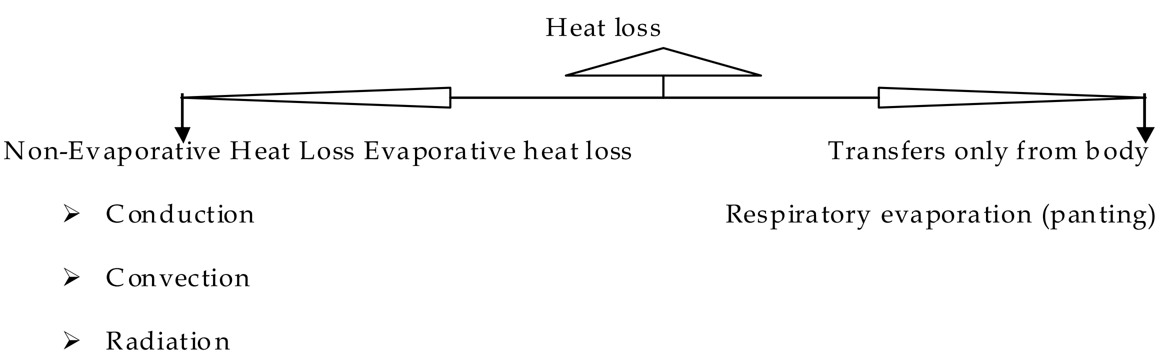
Exposure to high environmental temperature is of major concern for the poultry industry especially in hot regions of the world because of the poor performance and high mortality in chicken.[1]Birds can be reared in a thermoneutral zone (18 ^{0}C and 24 ^{0}C). When temperature increases beyond 30^{0}C it causes heat stress in poultry.[2]

Thermo Neutral Zone: The range of ambient temperature within which the animal doesn't need to expend any additional energy in order to regulate body temperature.[3]

Thermal balance: It is the sum of heat gain and heat loss.

Heat stress: It is a term commonly used to describe the birds response to elevated temperature and humidity, where abnormal response to increased heat dissipation such as, increase respiratory rate and panting. [3]

- High ambient temperature is of great concern in all types of poultry operations.



- Heat loss in poultry is limited due to feathering and the absence of sweat glands.
- When the temperature and relative humidity exceed the comfort level of a bird, it loses the ability to efficiency dissipate heat.
- High ambient temperatures compromise performance and productivity through reducing feed intake and decreasing nutrient utilization, growth rate and egg quality, which lead to economic losses in poultry.

Physiological mechanism

When animal first encounters a stressor, the neurogenic system is activated. It leads to release of neurotransmitters like NE and E. Stressors immediately results in the activation of the hypothalamic-pituitary-adrenal cortical system. When this system is activated, the hypothalamus produces corticotrophin-releasing factor (CRF), which in turn stimulates the pituitary to release adrenocorticotropic hormone (ACTH). Secretion of ACTH causes the cells of adrenal cortical tissue to proliferate and to secrete corticosteroids[4]

Why birds are more susceptible to high temperature?

- Lack of sweat glands
- Feather covered body
- Low surface area
- Higher Basal Metabolic Rate [5]

Consequences of heat stress

Effect of heat stress on feed intake and growth performance of chicken: At high environmental temperature feed intake of birds were decreased and ultimately decreased egg production and egg quality.[6]

High ambient temperature reduces the performance such as feed intake, live weight gain and feed efficiency in broilers.[7]

Effect of heat stress on nutrient retention: At high environmental temperature retention of dry matter, fat, protein and starch will be reduced and availability will lead to reduction in growth and production.[8]

Effect of heat stress on immunity: Heat stress causes release of corticosteroids and catecholamine's and causes lipid per oxidation of cell membrane mainly T-Lymphocytes, which have mainly immune-suppression action .[9]

Effect of heat stress on acid base balance: At high ambient temperature body temperature and respiratory rate of birds ultimately decrease PCO_2 level in blood plasma. In turn, bicarbonate buffer system decreases the concentration of carbonic acid and hydrogen ions and increase plasma p^H.[10]

In response to that, kidney increase bicarbonate ions excretion and decrease Hydrogen ion excretion as an attempt to keep birds in acid base balance. Excretion of more bicarbonate ion leads to respiratory alkalosis .[11]

Effect of heat stress on egg quality: In laying hens increase bicarbonate excretion ultimately decrease plasma concentration of bicarbonate ions causes limiting availability of anion required during formation of $CaCO_3$ crystals in the shell. So egg shell quality comprises .[12]

Nutritional strategies: Nutritional strategies include supplementation of:

I. Vitamins

II. Electrolytes

III. Amino acids

IV. Minerals[13]

Vitamins: Vita E, C and A used in poultry diet because of their anti stress effects and also because of their synthesis is reduced during the

Table 1: Effect of vitamins supplementation on feed intake and egg production

Vitamin C (mg/kg diet)	Feed intake (g/hen/day)	Feed efficiency (egg mass / feed)	Egg production (%)	Egg weight (g)
0	96.24	0.384^{b}	74.79^{b}	49.35
200	96.25	0.414^{a}	80.24^{a}	49.61
400	96.24	0.409^{a}	79.60^{a}	49.52
600	98.45	0.396^{ab}	79.23^{a}	49.32

Means with different superscripts within column differ significantly (P<0.05), n= 120 (4 Group), 46-54 wks, March – June, Ambient Temp. = 30 ^{0}C - 44 ^{0}C

heat stress.[14]

Why vitamins are necessary in heat stress: Vitamin E protect the lymphocytes and macrophages due to its anti oxidant property and enhanced proliferation and function of these cells.[15]

Vitamin A decrease Synthesis and secretion of corticosteroids which help to alleviate negative effect of heat stress.[16]

Vitamin C has been reported to enhance immune response by modifying corticosteroid synthesis in adrenal gland.[17]

Vitamin C plays a role in bone maturation by improving hydroxyproline production, which is required for collagen formation. Hence it is postulated that vitamin C stimulates 1, 25 dihydrocholecalciferol and increase calcium mobilization from bone, suggesting that vitamin C has important role in eggshell formation[8]

Effect of vitamin C supplementation on productive performance of WL

Panda *et al (*2007) carried out an experiment on 120 white Leghorn birds to found effect of vitamin C on feed intake and egg production and they reported that levels of Vitamin C supplementation did not influence food consumption but FCR was increased significantly due to supplementation of Vitamin C at either 200 or 400 mg/kg diet. Egg production increased significantly by supplementing 200 mg/kg Vita C as compare to control (Table 1).[17]

Ciftci et *al (*2005) conducted an experiment on 120 White Leghorn hens and reported that Hen day egg production was increased significantly and mortality percent decrease significantly in vitamin supplemented groups as compare to control group. [19]However, when both vitamin E and C were given in combination, the highest body weight was observed achieved, improved FCR and hen day egg production and decreased mortality up to 50% as compared to control group (Table 2).

Effect of vitamins supplementation on egg quality

Panda *et al (*2007) reported that egg quality parameters like specific gravity, shell breaking strength and haugh units were not influenced by Vitamin C supplementation. However, shell weight and shell thickness were improved significantly due to 200 mg/kg Vitamin C. No further benefits in these parameters could be observed by enhancing the level of supplementation beyond 200 mg/kg diet

Table 2: Effect of dietary vitamin E and C supplementation on growth and egg production performances in laying hens

Groups	Feed intake (g/hen/day)	Body weight (g)	Feed conversion ratio (g feed/ g egg)	Hen day egg production (%)	Mortality (%)
Control	92.02	1650.5^{a}	2.21^{a}	82.25^{d}	6.25^{a}
Vitamin E (125 mg/kg diet)	93.08	1680.0^{a}	1.88^{a}	84.25^{c}	5.08^{b}
Vitamin C (200 mg/kg diet)	93.09	1685.5^{ab}	1.85^{ab}	85.92^{b}	4.06^{c}
Vitamin E + Vitamin C	94.07	1697.0^{b}	1.72^{b}	88.29^{a}	3.01^{d}

Means with different superscripts within column differ significantly (P<0.05)
N= 120 Hyline-White leghorn hens, 150 days old (4 G), July 15th -sep.15th,Temp = 26 ^{0}C - 36 ^{0}C, R.H. = 50 % - 75 %

Table 3: Effect of Vitamin C supplementation on egg quality of White Leghorn layers

Vitamin C (mg/kg diet)	Specific gravity	Shell breaking Strength (Newton)	Shell weight (%)	Shell thickness (mm)	Haugh unit
0	1.074	28.05	8.99^{b}	0.353^{b}	64.24
200	1.075	27.36	9.26^{a}	0.365^{a}	63.82
400	1.074	29.14	9.24^{a}	0.361^{a}	64.28
600	1.073	27.04	9.28^{a}	0.363^{a}	65.06

Means with different superscripts within column differ significantly (P<0.05), n= 120 (4 G), 46-54 wks, March – June, Ambient Temp. = 30 0C - 44 0C

Table 4

Treatments	Shell thickness (mm)	Egg shell (%)	Egg yolk (%)	Hough unit
Control	0.2958	9.07	26.60^{b}	82.70
Vitamin E (200 mg/kg diet)	0.3021	9.34	28.33^{a}	84.25
Vitamin C (200 mg/kg diet)	0.2998	8.89	27.77^{ab}	85.27

(Table 3). [17]

Maziar et *al (*2007) found the effect of Vitamin E and C on egg quality of White Langhorne. They showed that egg shell thickness was higher than control but did not significantly.[20] However yolk % was increased significantly (Table 4).

Effect of vitamins supplementation on Humoral immune response of heat stress in Layers

Maziar et *al (*2007) also found the effect of vitamins supplementation on antibody titer of 36 White Leghorn and concluded that vitamin supplemented group significantly higher antibody titer as compare to control group (Table 5).[20]

Effect of vitamins supplementation on feed intake and growth performance of broilers under heat stress

Onu (2009) reported that birds fed supplemental ascorbic acid achieved significantly higher weight gain than control.[21] The 300 mg of ascorbic acid supplementation in broiler starter diet gave significantly (P<0.05) the highest body weight gain. Birds fed 300 mg/kg ascorbic acid of feed recorded significantly (P<0.05) lower mortality (Table 6).

An experiment conducted by Sahin *et al* (2001) to know the effect of vitamin E and A on performance of 120 broilers. They concluded that supplementation of Vitamin A and E either considered separately or as a combination, increased feed intake and body weight gain significantly in broilers.[14] However feed efficiency remains similar in all treatment. (Table 7).

Effect of vitamins supplementation on serum concentration of T_3, T4, ACTH and anti oxidant status in poultry

Table 5: Effect of vitamin E and vitamin C on immune response of laying hens

Treatments	Antibody titer (log_2)
Control	6.33^{b}
Vitamin E (200 mg/kg diet)	8.03^{a}
Vitamin C (200 mg/kg diet)	7.83^{ab}

Means with different superscripts within column differ significantly (P<0.05).
N= 36 (3 G) White leghorn (Hylinevariety), 42 days,
Temp = 33 ^{0}C - 35 ^{0}C, R.H. = 35 % - 55 %

Table 6: Effect of Ascorbic Acid supplementation on performance in broilers

Treatments	Body weight gain (g)	Feed intake (g)	Feed conversion ratio	Mortality (%)
Control	906.78^{c}	3422.46	3.78^{c}	13.33^{c}
Vitamin C (150 mg/kg)	1081.21^{ab}	3466.83	3.21^{ab}	6.67^{b}
Vitamin C (300 mg/kg)	1217.64^{a}	3463.98	2.86^{a}	3.33^{a}
Vitamin C (450 mg/kg)	1057.00^{b}	3492.60	3.30^{b}	6.67^{b}

Means with different superscripts within column differ significantly (P<0.05)
N= 120 Anak 2000, 4 G (7 day old) 35 days

Table 7: Effects of vitamin E (250mg/kg) and vitamin A (1500 IU/kg)supplementation on performance in broilers reared under heat stress

Treatments	Feed intake (g)	Body weight (g)	Feed efficiency (g body weight/g feed)
Control	3116.8[a]	1832.0[a]	0.58
Vitamin A	3151.8[b]	1890.14[b]	0.59
Vitamin E	3227.1[c]	1900.05[bc]	0.59
Vitamin A + Vitamin E	3314.8[d]	1985.78[c]	0.60

Means with different superscripts within column differ significantly ($P<0.05$)
N= 120 (Cobb 500 male broiler) 42 days, Temp = 32 ^{0}C, R.H. = 36-48 %

Sahin*et al* (2001) reported that Serum concentration of T3 and T4 were significantly higher and ACTH concentration in serum was lower in vitamins supplemented group as compared to the control group (Table 8).[14]

Table 8: Effects of vitamin E (250mg/kg) and vitamin A (1500 IU/kg) supplementation on serum concentration of T3, T4 and ACTH in broilers reared under heat stress

Treatments	T_3 (ng/ml)	T_4 (ng/ml)	ACTH (ng/ml)
Control	0.73[a]	4.11[a]	17.90[a]
Vitamin A	0.82[b]	4.42[b]	17.05[b]
Vitamin E	0.83[b]	4.45[b]	16.93[b]
Vitamin A + Vitamin E	0.88[c]	4.55[c]	16.13[c]

Means with different superscripts within column differ significantly ($P<0.05$)
N= 120 (Cobb 500 male broiler) 42 days, Temp = 32 ^{0}C, R.H. = 36-48 %

Table 9. Effect of vitamin C supplementation on anti oxidant status of Layers

Antioxidant enzymes	Supplemental vitamin C in diets (mg/kg)			
	0	200	400	600
Catalase, (K/g heamoglobin	284.71[c]	322.35[b]	361.01[a]	321.54[b]
Lipid peroxidation, (nmol MDA/mg protein)	286.26[a]	258.36[b]	243.67[c]	229.52[d]
Glutathione peroxidase, (unit/ml)	1.62	1.69	1.62	1.65

Means with different superscripts within column differ significantly ($P<0.05$)
n= 120 (4 G), 46-54 wks, March – June, Ambient Temp. = 30 ^{0}C 44 ^{0}C

Table 10: Effects of vitamin E supplementation on mineral concentration in broiler chicks

Vitamin E (mg/kg)	Ca (mg/dl)	P (mg/dl)
0	17.12	5.92
62.5	16.86	6.08
125	18.36*	6.68*
250	20.90*	7.04*
500	20.95*	7.09*

*= ($P<0.01$)
N= 150 male broiler chicks (5 G) 42 days, Temp = 30-35 ^{0}C, R.H. = 38-48 %

Panda *et al* (2007) found that Glutathione peroxidase activity was not influenced by supplementation of vitamin C in diet. However, Supplementation of vitamin C significantly reduced the activity of lipid peroxidase and increased activity of catalase (Table 9).[17]

Effect of vitamins supplementation on mineral concentration in poultry: Sahin*et al* (2002) observed that increasing dietary vitamin E supplementation caused linear increased in serum concentrations of Ca and P[22] (Table 10).

Panda *et al* (2007) studied the effect of vitamin supplementations on serum Ca and P concentration in laying hens. They reported that Supplemental Vitamin C did not influence serum inorganic phosphorus concentration.[17] However Concentration of Ca in serum increased significantly due to vitamin C supplement @ 400 mg/kg (Table 11).

Dietary electrolytes

- Supplementation of electrolytes in water

Table 11: Effect of vitamin C supplementation on mineral concentration parameters in laying hen

Parameters	Vitamin C (mg/kg diet)			
	0	200	400	600
Calcium (mg/dl)	12.31[b]	13.70[a]	14.24[a]	14.44[a]
Phosphorus (mg/dl)	5.08	5.99	5.02	5.26

Means with different superscripts within row differ significantly ($P<0.05$)
n= 120 (4 G), 46-54 wks, March – June, Ambient Temp. = 30 ^{0}C - 44 ^{0}C

Table 12: Effect of DEB on performance of laying commercial hens exposed to heat stress

Treatments DEB (m Eq/kg)	Feed intake (g/hen/day)	FCR (g feed/g egg)	Egg production (%)	Egg mass (g/hen/day)	Egg weight (g)
0	100.5	2.20	75.9	46.6	61.2
120	106	2.29	77.8	47.2	60.8
240	98.4	2.14	75.8	46.1	
360	104.7	2.40	73.6	44.8	60.9

N= 256 laying commercial hen, (4 G) (55-65 weeks), DEB (Dietary Electrolyte Balance) = NaCl + $NaHCo_3$ + $KHCO_3$ + NH_4Cl, Temp. = 30 ^{0}C -34 ^{0}C , R.H. = 70 %, Sept 23th – Dec 6th

enhance

√ Water consumption.

√ Increase tolerance to heat stress.

√ Improve production performance.

- Supplementation of Potassium Chloride @ 300 or 600 mg improved body weight, FCR, oxidative stress profile and other welfare parameters during both hot & hot humid summer but effect were more beneficial during hot humid summer.

Table 13: Effect of dietary electrolyte balance on egg shell quality of laying commercial hens exposed to heat stress

Treatments DEB (m Eq/kg)	Egg Shell Weight (g)	Specific Gravity	Egg Shell Thickness (mm)
0	5.46^{ab}	1.069^{b}	0.320^{b}
120	5.20^{b}	1.063^{b}	0.321^{ab}
240	5.5^{a}	1.071^{b}	0.336^{ab}
360	5.6^{a}	1.08^{a}	0.340^{a}

Means with different superscripts within column differ significantly (P<0.05)

Table 14: Effect of potassium chloride supplementation on performance of broiler

Treatments	Feed intake (g)	Body weight gain (g)	Feed conversion ratio(g gain/g feed)
Control	3260.3	1584.3^{b}	2.06^{a}
0.3% KCl	3296.0	1604.3^{b}	2.05^{a}
0.6% KCl	3324.5	1709.3^{a}	1.94^{b}

Means with different superscripts within column differ significantly (P<0.05)
N=135 Hubbard broilers, (3 G),7-42 days in May-June, Temp = 28-38 ^{0}C , R.H.= 50-55 % , Control = Tap water without KCl 0.3 % and 0.6 % KCl (w/vl) by supplementing 3 and 6 g of KCl, respectively.

Hooge (1995) stated that Electrolytes are compounds which are dissolved and dissociated into positively and negatively ions in a suitable medium.[23]

Effect of Electrolytes supplementation on performance and egg quality of laying hen Under Heat Stress: Nobakht *et al (*2006) concluded that DEB levels did not significantly (P<0.05) affect egg production, FCR, Feed intake, Egg mass and Egg weight[24] (Table 12).

They also found DEB effect of egg shell quality and reported that Egg Shell weight and specific gravity in 240 and 360 level of DEB increased significantly (P<0.01). Egg shell thickness increased with increasing electrolyte balance (Table 13).

Effect of Electrolytes supplementation on performance of broiler: Ahmad *et al (*2008) carried out an experiment on broilers to know the effect of electrolytes supplementation on performance. They reported that water treatment with 0.6% KCl resulted in significantly higher BW gain.[A significantly improvement in FCR was noted in 0.6% KCl

Table 15: Effect of water supplements on the body weight gain (g) of broiler chicks

Weeks	Control	Acetic Acid	$NaHCO_3$	KCl
2	304.7^{c}	380.9^{a}	375.1^{b}	255.7^{d}
4	830.0^{d}	995.0^{a}	985.4^{b}	900.0^{c}
6	1601.7^{d}	1950.3^{a}	1868.6^{b}	1794.3^{c}

Means with different superscripts within row differ significantly (P<0.05)
N= 200 Hubbard Chicks (4 G), age= 0-6 week, Temp = 30-35^{0}C, Control = No Supp., Acetic Acid @ 1.5 ml/L water, $NaHCO_3$ @ 0.5%, KCl @ 0.15%

Table 16: Effect of potassium chloride supplementation on carcass weight of broilers

Treatments	Carcass weight (% of live weight)
Control	72.2
0.3% KCl	74.5
0.6% KCl	74.6

N=150 Hubbard broilers, (3 G), 42 days, Control = Tap water without KCl 0.3 % and 0.6 % KCl (w/vl) by supplementing 3 and 6 g of KCl, respectively.

Table 17: Effect of Ascorbic Acid and Potassium Chloride Supplementation on dressing percent of Broiler Chicks

Groups	Dressing Percent
Control	77.10[ab]
T1	77[b]
T2	78.15[ab]
T3	78.24[a]

n = 420 Rose Chick (4 G), 3-7 weeks, T1 = 0.1 % KCl/L + 200 mg/kg Ascorbic Acid, T2 = 0.1 % KCl/L + 400mg/kg Ascorbic Acid, T3 = 0.1 % KCl/L + 600mg/kg Ascorbic Acid

supplement group[25] (Table 14).

The three water supplements used by Hassan *et al (*2009) in this study, acetic acid, $NaHCO_3$ and KCl have improved weight gains in broiler chicks at 2, 4 and 6 wks of age except KCl treated groups at 2 wks of age which may be due to decreased water consumption at the first week[26] (Table 15).

Effect of electrolytes and vitamins supplementation on carcass quality: Ahmad *et al (*2008) found no significant effect of KCl on carcass quality of 150 broilers[25] (Table 16).

Ihsan et *al (*2011) stated that dressing percentage was significantly higher in T3 compared to T1[27] (Table 17).

Table 19: Effect of Ascorbic Acid and Potassium Chloride Supplementation on Performance Broiler Chicks Reared under Summer Condition

Treatments	Body Weight Gain (g)				
	21-28 days	28-35 days	35-42 days	42-49 days	21-49 days
Control	471	459	463[b]	461	1857[b]
T1	405	457	448[b]	441	1753[c]
T2	461	456	520[a]	496	1935[a]
T3	420	459	479[ab]	448	1807[b]

Means with different superscripts within column differ significantly (P<0.05)
N= 420 Rose Chick (4 G), 3-7 weeks, T1 = 0.1 % KCl/L + 200 mg/kg Ascorbic Acid, T2 = 0.1 % KCl/L + 400mg/kg Ascorbic Acid, T3 = 0.1 % KCl/L + 600mg/kg

Effect of combination of electrolytes and vitamins: Roussan et *al (*2008) reported that total feed consumption, FCR and mortality rate of birds in the HS-NON group were significantly greater than those in the HS-SUP group.[28] These clearly indicated that a significantly lowered mortality rate and FCR occurred under cyclic heat stress temperatures when ascorbic acid, ASA, KCl and $NaHCO_3$ were supplemented (Table 18).

Ihsan et *al (*2011) concluded that treatment had no effect on during the periods 21-28, 28-35 and 42-49 days old broilers.[27] In all experiment period T2 achieved significant mean highest gain (Table 19).

Amino acids

Protein requirement is decreased bz of

Table 18: Effect of supplementation of Ascorbic Acid, Acetylsalicylic Acid, Sodium Bicarbonate and Potassium Chloride on the Performance of Broiler (35 days age)

Groups	Total feed consumption (g/bird)	Live Body Weight Gain (g/bird)	Feed conversion ratio	Mortality Rate (%)
Control	910.2[a]	592[a]	1.538[c]	1.33[c]
HS-SUP	844.9[b]	443[b]	1.907[b]	8.0[b]
HS-NON	762.1[c]	310[c]	2.458[a]	17.3[a]

Means with different superscripts within column differ significantly (P<0.05)
N= 225 Female Ross broiler, (3 G) 7 days, Control = Thermo neutral, HS- SUP =Cyclic Temp. + Ascorbic Acid and ASA @ 62.5 mg/L, $NaHCO_3$ @ 75 mg/L and KCl @ 125 mg/L in water, HS-NON =Cyclic Tem. Without Suppl., Cyclic temp = 30-33 ^{0}C for 12 hrs, 21-23 ^{0}C for 12 hrs.

Table 20: Effect of methionine supplementation in the ration of commercial layers during summer

Methionine (%)	Feed Intake (g/hen/day)	Feed Conversion ratio (g feed/g egg)	Egg production (%)	Egg weight (g)	Broken eggs (%)	Respiratory rate no./minute
0.00	108.3[a]	122.5[a]	88.4[a]	53.5	2.7[a]	147
0.04	104.8[b]	114.8[b]	91.3[b]	53.7	1.7[a]	136
0.08	104.3[b]	113.8[b]	91.9[b]	54.4	1.3[b]	131

Means with different superscripts within column differ significantly (P<0.05)
N= 720 hens of commercial strain A of 28 wks age (3G) 6 wks, Temp. = 32 – 36 ^{0}C

suppression in Production performance. High protein diet during heat stress decrease growth rate & meat yield. Protein has high heat increment. Diets containing lower protein levels & supplemented with limited amino acids , methionine, lysine gave better results.

Ravikiran and Devegoeda, (1998) reported that significant (P<0.05) improvement in egg production and reduction in feed intake in both levels of methionine supplementation. However the differences between the two supplemented groups were non-significant, both with respect to egg production and feed intake. Feed efficiency improved significantly. Significantly decreased in broken eggs[29] (Table 20).

Bunchasak and Silapasorn, (2005) reported that the Low-CP diet with 0.26% methionine had significantly depressed feed consumption of hens compared to other experimental groups (P<0.01).[30]Methionine intake was significantly linearly increased as the supplemental levels increased. In addition, increased dietary Met intake significantly improved FCR and Feed consumption of hens. Adding Methionine at 0.38% or 0.44% diet better effect than other level (Table 21).

Table 21: Effects of additional methionine in low-protein diet on performance of laying hens from 24 to 44 weeks of age under tropical condition (35°C)

Methionine Level (%)	Group	Feed intake (g/day)	Feed Conversion Ratio (g feed/g egg)	Mortality (%)
0.38	Control (16% CP)	98.14[a]	2.33[c]	8.22[b]
0.26	Treatment (14% CP)	87.85[b]	2.63[a]	11.75[a]
0.30		98.21[a]	2.60[a]	6.07[b]
0.38		99.73[a]	2.47[b]	5.89[c]
0.44		99.98[a]	2.43[b]	5.87[c]

Means with different superscripts within column differ significantly (P<0.05)
N= 480 Commercial (Isa brown) laying hen, Temp = 24 – 36 ^{0}C, R. H. = 60-70 %

Minerals

- Addition of zinc @ 48 or 96 mg/kg of basal diets significantly improved body weight, FCR, immunoresponse, oxidative stress profile & other welfare parameters during hot & hot-humid summer. but results were more effective @ 96 mg/kg level that too during hot summer.
- Dietary supplementation of chromium (2.49 cr./kg diet) from 20 mg chromium picolinate was beneficial to reduce the adverse effect on growth performance, immunity and oxidative stress profile caused by higher ambient temperature during extreme summer.(Kulkarni, 2012)

Sahin*et al* (2002) stated that heat stress increases mineral excretion and also decreases concentrations in serum and liver.

Table 22: Effect of supplemental zinc and vitamin A on performance of broiler chicken reared under heat stress

Treatments	Feed intake (g)	Feed Conversion Efficiency	Live weight Gain (g)
Control	3101[c]	2.12[b]	1458[c]
Zn (30 mg/kg)	3150[b]	2.06[b]	1517[b]
Vit A (1500 IU/kg)	3162[b]	2.07[b]	1525[b]
Zn + Vit A	3200[a]	2.03[c]	1570[a]

Means with different superscripts within column differ significantly (P<0.05)
N= 120, ten day old male chick, (4 G), June 25– Aug 28

Table 23: Effect of supplemental zinc and vitamin A on carcass quality of broiler chicken reared under heat stress

Item	Control	Zn	Vitamin A	Zn+ vitamin A
Live weight (g)	1463[c]	1522[b]	1530[b]	1591[a]
Hot carcass yeild (%)	58.4[c]	60.8[b]	61.1[b]	63.2[a]
Chilled carcass yeild (%)	63.3[c]	64.0[b]	64.4[b]	66.9[a]
Heart wt. (%)	0.38[c]	0.40[b]	0.40[b]	0.43[a]
Liver wt. (%)	1.73[c]	1.78[b]	1.77[b]	1.81[a]
Abdominal fat wt. (%)	2.16[a]	2.13[b]	2.12[b]	2.08[c]

Mean values with different superscripts in a row with differ significantly ($P<0.05$)
N= 120 ten day old male chick 42 days

Kucuk *et al (*2003) concluded that live weight gain increased and feed efficiency improved greatly in chickens fed supplemented diets compared with the chicks fed the control diet.[31] However, a combination of zinc and vitamine A, rather than each separately, provided a greater performance (Table 22).

Kucuk *et al (*2003) also found effect on carcass quality and reported that combination of zinc and vitamine A, rather than each separately, provided a greater performance[31] (Table 23).

Other nutrients & feed additives

- Supplementation of probiotic *lactobacillus strains* may enrich diversity of micro flora in chicken.
- Restore microbial balance in jejunum & caeca of chicken.
- Reduce harmful effects of heat stress.

Dietary fat

It is recommended that the energy content of the diet be increased during hot weather. The use of supplemental fat is suggested. Dietary fat increases palatability of feeds and reduces the amount of heat increment that is produced during its utilization in the body.

- Inclusion of fats in the diet should be considered on hot days, particularly for broiler chickens, in order to maintain daily energy intake in line with the requirements for growth.
- But On many tropical farms, it is common practice to exclude fat from the diet during summer and include it during winter. It is though, that the energy requirement of broilers is less in summer than in winter. (Salah H. *et al., 2012)*
- Recent studies, however, have shown that the inclusion of fat in diets for heat-stressed broilers helps improve feed intake and performance, because of the lower heat increment of fat compared to other energy sources such as carbohydrates or proteins.
- Care must also be taken when selecting the fat source to be incorporated into the diet. Generally fat sources having large amounts of polyunsaturated fatty acids, such as soybean oil, canola oil, walnuts, flaxseed oil and fish oil, should all be avoided or be used at minimal levels in the diet.
- This is due to the fact that such sources have low levels of antioxidants and are especially susceptible to oxidative rancidity and destruction of vitamin A and E, with resulting changes in the flavour of poultry meats.

Water

- Water requirement increase during hot periods.
- 6% water intake increase per degree rise in temperature from that at 20 ^{0}C temperature.
- 25% more drinking space should be provided.
- Water below body temperature will certainly aid in heat dissipation.

Drug administration

- During heat stress need proper Care and Management.
- Medicines should be administered at the early morning when temperature is low.

- Drugs should be administered with cool, fresh & quality feed.

Disinfection & hygiene

- All-in & all-out system of poultry management in hot climates is most preferred.
- Appropriate disinfection programme is followed between the batches.
- In high temperature there may be rapid evaporation of disinfectant solution resulting in less contact time.

Conclusions

Heat stress reduces the production performance of chicken leads to immunosupression and increases the mortality rate in chicken. All the nutritional supplements (e.g. vitamins, zinc, Kcl) have functions in relation to heat stress. Suitable mineral & vitamin premixes can be developed for heat stressed chickens for improved performance, welfare & reducing feed cost. Heat stress increase the serum concentration of ACTH which increase corticosteroid level and in turns reduces the production. Dietary supplementation of vitamin C (200 mg/kg) improved the egg production and egg shell quality in laying hen during summer stress. Ascorbic Acid supplementation (300 mg/kg of diet) improved body weight gain, feed conversion ratio and decreased the mortality in broilers. Dietary supplementation of anti-oxidant vitamins (vitamin E or vitamin C in combination) is helpful to maintain the growth performance, egg production and improvement in egg quality. Vitamin E (250 mg/kg diet) increased serum concentration of T_3, T_4 and decreased concentration of ACTH thereby production is maintained. Low protein diet (14%) with provision of additional methionine @ 0.44% maintained the production performance of laying hens. Supplementation of Dietary Electrolyte Balance like NaCl, $NaHCO_3$, $KHCO_3$ and NH_4Cl (360 m Eq/kg) in heat stress can improve eggshell quality of laying hens. Supplementation of 0.1% KCl with 400 mg vitamin C showed better performance for broilers reared under heat stress. Zinc in combination with vitamin A improves performance and carcass quality of broiler under heat stress.

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