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Vitamin C Supplement to Laying Hen's Ration at High and Normal Temperature

G.A.R. Kamar, M.A. Kicka, O.E. Mohamed* and E. Omer

Faculty of Agriculture and Veterinary College, Cairo University, Giza, Egypt.

THE EXPERIMENT was carried out for a period of three months, April, May and June, where 96 laying hens at 8 months of age were divided into two equal groups. The first group was maintained under high temperature (90° F.). The second group was reared under normal conditions. Every group was divided into four subgroups, to be supplied with 0, 50, 100, 200 and 250 ppm ascorbic acid respectively. The laying hens (without supplement) reared under high temprature showed reduction in feed consumption and efficiency, egg production "number and weight", shell thickness, serum calcium and phosphorus and thyroid weight. High air temperature increased body temperature, respiration rate, blood pressure and mortality. Addition of ascorbic acid to the laying ration caused an increase in feed consumption, feed efficiency, egg production, shell thickness, serum calcium and phosphorus and thyroid weight. Body temperature and mortality rate was decreased by adding ascorbic acid to the ration. Ascorbic acid supplement did not affect blood pressure.

During the laying period the high level of ascorbic acid (250 ppm) was more effective on the economic characters, specially puriug high temperature.

Results on the effect of ascorbic acid on egg production showed wide contraversial. The addition of ascorbic acid to laying rations increased the egg production (Essary and Holmes, 1944, and Hunt and Aitken, 1962). Ahmed *et al.* (1966) showed that dietary ascorbic acid supplementation assists in counteracting the high environmental temperature conditions for laying birds without any reduction in egg production. On the other hand, Thornton and Moreng (1958*a* and *b*), Harms and Waldroup(1961),Sullivan and Kingan(1962), and Roberson and Francis (1965 and 1966) reported that the addition of ascorbic acid to the laying ration did not affect egg production. Also, Thornton and Moreng (1959) showed that egg production was not affected by the presence of ascorbic acid in the diet under cool and warm environmental temperature.

Supplementation with vitamin C had no or very slight increasing effect on the egg weight. Hens supplemented with vitamin Cand subjected to high temperature showed an increase in egg weight (Thornton, 1959*a*, and Perek and Kendler, 1962). El-Boushy (1966 found that birds treated with vitamin C showed a slight rise in egg weight. Also, he found that vitamin C addition diminished the decline in egg weight in hot climate but this effect was statistically not significant.

On the other hand, Heywang and Kemmerer (1955) and Heywang *et al.* (1963) found that no appreciable change in egg weight occurred when the diet was supplemented with ascorbic acid.

Concerning the feed efficiency, Perek and Kendler (1962) found that the feed efficiency was higher in groups supplemented with vitamin C. However, Wilkinson (1961) and Roberson and Francis (1965) showed that addition of vitamin C had no effect on feed efficiency during the laying period.

During the laying period, the addition of vitamin C to the diet increased the feed consumption and this increment was significant when birds kept under 80-82° F. (Thornton and Moreng, 1958*b*) and was slight under the cool environmental conditions (Thornton and Moreng, 1959).

Reports in the literature on the effect of the addition of vitamin C to the laying ration on the egg shell quality are not contradictory. Thornton and Moreng (1958a) and Thornton (1960*a* and *b*), reported that shell thickness was increased, specially during period of heat stress, by supplementation of vitamin C. Similar findings were reported by Thornton and Moreng (1958*b*) and Ahmed *et al.* (1966) who suggested that ascorbic acid may have a stimulatory influence on the thyroid activity particularly under the conditions of increased environmental temperature. Sullivan and Gehle (1962) explained the increased egg shell thickness was by promoting the transfer of serum calcium to the shell gland of the oviduct.

On the other hand, Pepper *et al.* (1960) found that the addition of vitamin C to the laying ration had no significant effect on specific gravity of eggs when the hens reared under 75-80°F. Wilkinson (1961) confirmed this result. Also, under hot environmental temperature, it was reported that supplementation of ascorbic acid had no influence on egg shell thickness (Heywang and Kemmerer, 1955, Thornton, 1960*b*; Hunt and Aitken, 1962 and Perek and Kendler, (1962). Similar findings were reported by Harms and Waldroup (1961) and Heywang *et al.* (1963) but using sodium ascorbate as a supplement. Also, Roberson and Francis (1965 and 1966) found that shell thickness and roughness was not affected by ascorbic acid, but the percentage weight of shell to the eggs was significantly increased.

In the cold climate (55 ± 5°F.) no significant effect of vitamin C addition on shell thickness, shell percentage and specific gravity was observed (El-Boushy, 1966).

When S.C. White Leghorn hens were fed rations containing 20 mg ascorbic acid/lb. they required less calcium to produce a pound of egg shell than did the other birds (Essary and Holmes, 1944). On the other hand, Thornton (1960 *b*) found that the addition of vitamin C (20 mg/lb of ration) increased calcium required for shell formation.

The response of plasma calcium, in hens, to ascorbic acid may be influenced by factors other than heat stress, namely dietary protein level, calcium level and the metabolic rate (Thornton, 1960*a* and *b* and 1961 *b*). Vitamin C significantly raised the calcium level in the plasma in the hot environment, accompanied by a significant improvement in shell quality (El-Boushy, 1966). On the other hand, Sullivan and Gehle (1962) reported that ascorbic acid (25 mg/lb of ration) slightly decreased calcium levels in the blood. Therefore, it was thought that ascorbic acid may increase egg shell thickness by promoting the transfer of serum calcium to the shell gland of the oviduct.

Also it was shown that dietary ascorbic acid supplementation assists in counteracting the high environmental temperature conditions for laying birds (Ahmad *et al.*, 1966). Vitamin C had a tendency to reduce body temperature in heat stressed birds (Ahmed and Moreng, 1944 and Subaschandran and Balloun, 1966).

At the same time, it was reported that in heat stressed birds (30°C.) vitamin C did not affect blood pressure significantly (Subaschandran and Balloun, 1966).

The present experiment was conducted to study vitamin C supplementation on feed efficiency, egg production, mortality rate, body temperature, respiration rate, blood pressure, serum calcium and phosphorus and thyroid weight in mature hens maintained under high and normal environmental temperature.

Experimental

Animal and diet

96 Fayoumi hens, 8 months of age, were kept in individual laying cages during the experimental period (April, May and June). Each cage was provided with feeder and waterer. The hens were distributed at random into two equal groups. The first group was housed under high temperature of 90°F. during the period of the experiment (the cages were placed in houses heated by an electric thermostatic heater to keep the room temperature almost constant. While hens in the second group were reared under normal temperature with an average 71°F. (average air temperature was 61, 71 and 80°F during April, May and June respectively).

Every group was divided into four equal subgroups. The egg production in the month prior to the experimental treatment (March) was almost equal in the four subgroups. Rations of subgroups were supplied with 0, 100, 200 and 250 ppm ascorbic acid. The ration used was composed of 55% crushed grains and 45% mash. The grain mixture included 10% barley, 35% maize, 10% horse beans. The mash ingredients were 12.5% wheat bran, 12.5% rice bran, 15% decorticated cotton seed meal and 5% fish meal. A supplement of 0.5% common salt, 1.5% bone meal, 3.5% calcium carbonate and 2 g feed supplement Pfizer vitamin A+D_3 per kg diet (vitamin A 5000 IU/g and vitamin D_3 500 IU/g). Meals were offered twice daily at morning and afternoon ad libitum. Fresh water was adequately supplied.

Individual daily records for egg number, egg weight, feed consumption and mortality were collected. Shell quality tests, weight, percentage and thickness were carried out on 48 egg samples per subgroup within one week. (Drant and Shrader, 1952).

Monthly records for body temperature and respiration rate between 12 noon to 2.00 p.m. were tested in random group samples of 10 hens.

At the end of the experiment, 6 hens from each subgroup were used to estimate blood pressure by the manometric method (Sturkie, 1954).

After measuring blood pressure, blood samples were collected from the same birds. The serum of each hen was used for the determination of calcium after Roe and Kahn (1929), and phosphorus after Fiske and Subbarow (1925).

Statistical analysis was carried out according to Steel and Torrie (1960).

Results and Discussion

Effect of ascorbic acid on feed consumption and feed efficiency

During the laying period, the accumulated feed intake per bird for three months indicates that birds reared under high temperature consumed less feed than those reared under normal temperature (Table 1), a fact which is greatly attributed to less appetite when air temperature drifts up to 90°F (Huston *et al.*, 1957; and Longhouse *et al.*, 1963).

TABLE 1. **Average feed consumed and feed efficiency for the different groups treated with ascorbic acid (April-June).**

Temperature	Levels of ascorbic acid (ppm)	Feed consumed (g/hen)	Feed efficiency kg feed/kg egg
High 90 F . .	0	9077	7.67
	100	9303	5.07
	200	9452	4.64
	250	9687	4.12
Normal	0	9229	6.71
	100	9419	5.60
	200	9578	4.69
	250	9853	4.18

Ascorbic acid supplementation to the ration of the laying hens increased feed consumption (Tabe 1). The effect of ascorbic acid on feed consumption was more pronounced under high temperature than under normal temperature and also the high level of ascorbic acid was more effective than the low level.

Feed efficiency per one kilogram of egg mass was much higher in the hens reared under normal temperature than in hens reared under high temperature (Table 1).

Addition of ascorbic acid to the ration of the laying hens improved feed efficiency. Theis improvement was more pronounced under high temperaure than under normal one. Also the feed conversion was higher under the high level than the low level. Thornton and Moreng (1959) proposed that ascorbic acid had stimulating influence on the thyroid gland. This may in turn improve the feed efficiency·

Effect of ascorbic acid on egg production

Egg number

It is evident from Table 2 that addition of ascorbic acid to the ration of laying hens for three months increased egg number. The supplementation with 100, 200 and 250 ppm ascorbic acid caused 45, 57, and 79% increase in egg number under high temperature and 24, 32 and 57% increase under normal temperature respectively. From these results, it can be noted that ascorbic acid is more effective on egg number under high temperature than in normal temperature. Also, the high levels of ascorbic acid had a pronounced effect on egg number than the low levels.

The beneficial effect of ascorbic acid on egg number may be due to the relative success of birds in increasing feed consumption and feed efficiency. Also, this may be due to the effect of ascorbic acid in maintaining the normal physical conditions of the body, body temperature, respiration rate.

Ahmed *et al.* (1966) showed that dietary ascorbic ascid supplementation assist in counteracting the high environmental temperature conditions for laying birds.

It is clear also that hens reared under high temperature without ascorbic acid (o ppm) produced lower eggs than those reared under normal temperature. Here the reduction percentage in egg number was 11%.

Statistical analysis in Table 3 shows that the differences in egg number due to ascorbic acid and months were highly significant ($P<0.01$) while the difference due to temperature was not significant. This result may be due to the increase in the normal environmental temperature especially at the end ofexperiment which reached 84°F. The interaction between levels and months was highly significant ($P< 0.01$).

TABLE 2. Average egg number per hen in the different groups treated with ascorbic acid.

Temp.	Months	Levels of acorbic acid (ppm)			
		0	100	200	250
High 90°F	April	10.58	16.58	20.33	21.67
	May	11.33	18.64	16.75	21.00
	June	7.88	11.00	12.82	14.27
	Average	10.60	15.47	16.63	18.98
Normal	April	13.83	14.25	19.92	22.33
	May	12.83	16.36	14.92	18.58
	June	9.00	13.50	12.33	15.08
	Average	11.89	14.70	15.72	18.66

TABLE 3. Analysis of variance of egg number for the different groups treated with ascorbic acid.

S.V.	d.f.	M.S.	F.
Levels (L)	3	639.59	27.82**
Temperature (T)	1	7.11	0.31
Months (M)	2	695.80	30.27**
L X T	3	13.44	0.58
L X M	6	86.15	3.75**
T X M	2	34.69	1.51
L X T X M	6	17.15	0.75

** = $P < 0.01$

Egg weight

Ascorbic acid addition to the ration of laying hens for three months abolished the decline in egg weight by the effect of hot climate (Table 4) this effect was statistically highly significan (Table 5) Also supplied with ascorbic acid and reared under normal temperature showed increase in egg weight. However, the increase in egg weight due to ascorbic acid is more pronounced under high temperature than normal temperature. The higher level of ascorbic acid (250 ppm) gave larger eggs than lower levels.

As far as the effect of ascorbic acid on egg weight under high temperature is concerned, El-Boushy (1966), Perek and Kendler (1962) and Thornton (1959 a) showed that hens given ascorbic acid and maintained under high temperature gave larger eggs.

Egg shell thickness

Hens reared under high temperature with or withuot ascorbic acid laid eggs with thinner shell (Table 6). This agrees with findings of Warren and Schnepel (1939) and Wilhelm (1940) and Brant *et al* (1953). Conrad (1939) mentioned that shell secretion is probably retarded at high temperatures by diminished intake of calcium in the feed and possibley also by reduced capacity of the blood stream to carry calcium.

Under high and normal temperatures the addition of ascorbic acid to the ration of laying hens increased shell percentage and thickness especially by high levels. The supplementation with 100, 200 and 250 ppm ascorbic acid caused 8, 12 and 19% increase in shell thickness under high temperature and 4, 8 and 21% increase under normal temperature respectively.

Differences between levels and temperature treatments were highly significant (Tabel 7).

Effect of ascorbic acid on physiological reactions

During the laying period, the birds showed higher body temperature, respiration rate and blood pressure in groups reared under high temperature (Table 8). Concerning the stress effect of high temperature, many workers, such as Randall (1943) and Wilson (1948) and also Sturkie (1954) who came to the conclusion that the critical temperature of the environment, above which body temperature of hens begin to rise is about 80 - 85° F. Heat elimination is controlled largely by heat dissipation through activated respiration, as birds are not equipped with sweatglands.

Ascorbic acid supplementation to the ration of laying hens for three months seemed to decrease body temperature by increasing respiration rate under normal and high temperatures (Table 8). The differences were highly significant (Table 9). The groups which received the high level of ascorbic acid were of considerably higher respiration and lower body temperature than groups which received the low level.

TABLE 4. Average egg weight (g) for the different groups treated with ascorbic acid.

Temp.	Months	Levels of ascorbic acid (ppm)			
		0	100	200	250
High 90F	April	43.64	44.75	44.86	44.52
	May	39.77	42.76	40.64	44.31
	June	36.90	40.29	39.38	41.60
	Average	40.50	42.73	41.70	43.50
Normal	April	43.05	42.43	45.58	45.53
	May	42.57	42.28	43.47	41.98
	June	39.68	38.78	40.75	38.93
	Average	41.95	41.27	43.26	42.14

TABLE 5. Analysis of variance of egg weight for the different groups treated with ascorbic acid.

S.V.	d.f.	M.S.	F-value
Levels (L)	3	31.09	2.840**
Temperature (T)	1	00.24	0.022
Months (M)	2	482.22	43.998**
L X T	3	48.59	4.433**
L X M	6	9.96	0.909
T X M	2	8.36	0.763
L X T X M	6	—	1.588

** < P — 0.01.

TABLE 6. Average shell percentage and shell thickness (mm) for the different groups treated with ascorbic acid.

Levels of ascorbic acid (ppm)	High (90°F)		Normal	
	Shell %	Shell thickness	Shell %	Shell thickness
0	12.01	2.287	12.98	0.307
100	13.32	0.310	13.45	0.321
200	13.63	0.320	13.69	0.332
250	14.01	0.341	14.21	0.370

TABLE 7. Analysis of variance of shell thickness for the different groups treated with ascorbic acid.

S.V.	d.f.	M.S.	F-Value
Levels (L)	3	0.028276	20.33**
Temperature (T)	1	0.015034	10.81**
L X T	3	0.000811	0.58

** = $P < 0.01$.

Addition of ascorbic acid to the ration of hens showed no significant effect on blood pressure under different environmental temperature (Tables 8 and 9).

These results are in good agreement with several authors.(Ahmad and Moreng, (1944); Grimes and Moreng, (1965) ; and Subaschandran and Balloun, (1966) .

Effect of ascorbic acid on serum calcium and phosphorus

High temperature had highly sifgnificant effect on decreasing the levels of serum calcium and phosphorus (Table 10). This effect caused a highly significant reduction in shell thickness (Table 6). Warren and Schnepel (1939) and Conrad (1939) reported similar results.

TABLE 8. Average body temperature, respiration rate and blood pressure for the different groups treated with ascorbic acid during the laying period.

Temp.	Levels of ascorbic acid (ppm)	Body temp. (°F.)	Respiration rate (/minute)	Blood pressure (mm Hg.)
Hig 90F . . .	0	112.7	158.3	140.4
	100	111.1	165.7	140.3
	200	110.8	171.4	138.2
	250	109.0	180.7	137.7
Normal	0	110.9	126.0	134.9
	100	109.1	135.6	134.8
	200	108.6	141.4	133.6
	250	107.3	156.8	133.2

TABLE 9. Analysis of variance of body temperature, respiration rate and blood pressure for the different groups treated with ascorbic acid during the laying period.

Items	S.V.	d.f.	M.S.	F
Body temperature	Levels (L) . .	3	31.70	10.82**
	Temp. (T) . .	1	944.07	322.2 **
	L X T . . .	3	0.63	0.22
Respiration rote	Levels (L) . .	3	656.77	162.97***
	Temp. (T) . .	1	460250.41	114206.06**
	L X T . . .	3	2357.10	584.89*
Blood . . . . . Pressure	Levels (L) . .	3	26.67	1.90
	Temp. (T) . .	1	776.02	55.47**
	L X T	3	1.02	0.07

** — $P < 0.01$

During the laying period, ascorbic acid raised the serum calcium and phosphorus levels in normal and high temperature (Table 10). The average increase in serum calcium and phosphorus were 1.64 and 0.35 mg /100 ml serum under high temperature and 0.51 and 0.30/100 ml serum under normal temperature respectively. The differences due to levels of ascorbic acid were highly significant (Table 11).

TABLE 10. Average serum calcium and phosphorus (m /100 ml of serum) for the different groups treated with ascorbic acid during the laying period.

Temperature	Ascorbic acid (ppm)	Calcium	Phosphorus
High 90° F . .	0	13.92	5.83
	100	14.67	6.03
	200	15.82	6.23
	250	16.18	6.28
Normal	0	16.53	6.32
	100	16.83	6.55
	200	17.00	6.58
	250	17.28	6.75

TABLE 11. Analysis of variaace of calcium and phosphorus for the different group treated with ascorbic acid during the laying period.

items	S.V.	d.f.	M.S.	F-value
Calcium	Levels (L) . .	3	5.46	30.35**
	Temp. (T) . .	1	37.45	208.06**
	L X T . . .	3	1.67	9.28**
Phosphorus	Levels (L) . .	3	0.427	9.49*
	Temp. (T) . .	1	2.470	54.89*
	L X T	3	0.020	0.44

** = $P < 0.01$.

This increase in serum calcium was accompanied by a highly significant improvement in shell thickness (Table 6). El-Boushy (1966) and Thornton (1960b) reported that vitamin C had a marked influence on calcium metabolism.

The high level of ascorbic acid supplementation caused greater increase in serum calcium and phosphorus than the low level.

Effect of ascorbic acid on thyroid weight

It is evident from Table (12) that rearing the laying hens under high temperature decreased absolute and relative thyroid weight, although this difference was not significant (Table 13). Under high and normal temperatures the addition of ascorbic acid to the ration of laying hens for three months increased the absolute and relative thyroid weight, except in the group receiving ascorbic acid at level 100 ppm and reared under normal temperature, which gave lower thyroid weight per 100 g of body weight. The effect of ascorbic acid on relative thyorid weight was more pronounced under the high than the normal temperature. The higher level of ascorbic acid increased absolute and relative thyroid weight that the lower level. The differences in the thyroid weight due to levels of ascorbic acid were highly significant (Table 13).

Effect of ascorbic acid on mortality rate

During the laying period mortality rate increased in the hens reared under high temperature (Table 14). As far as high temperature is concerned, our findings are in agreement with the results obtained by Muller (1962).

Ascorbic acid supplementation to the ration of laying hens decreased mortality rate (Table 14). Our results are similar to those obtained by Perek and Kendler (1962).

TABLE 12. **Average body weight (g), thyroid weight (mg) and thyroid weight per 100 grams of body weight for the different groups treated with ascorbic acid during the laying Period.**

Levels of ascorbic acid (opm)	Temperature					
	High 90°F			Normal		
	Body weight	Thyroid weight	Thyroid w/100 g body wt.	Body weight	Thyroid weight	Thyroid w/100 g body wt.
0	1233.3	100.00	8.11	1013.3	115.50	11.40
100	1138.7	116.50	10.23	1243.7	130.17	10.47
200	1177.3	131.67	11.18	1239.3	147.67	11.92
250	1272.7	163.17	12.82	1218.7	180.66	14.82

TABLE 13. Analysis of variance of thyroid weight for the difference groups treated with ascorbic acid during the laying period.

S.V.	f.d.	M.S.	F-value
Levels (L)	3	9046.06	8.25**
Temp. (T)	1	2945.33	2.69
L X T	3	7.50	0.0068
** = P < 0.01.			

TABLE 14. Mortality rate for the different groups treated with ascorbic acid during the laying period.

Levels of ascorbic acid (ppm)	Mortality percentage	
	High temperature	Normal temperature
0	33.4	16.7
100	16.07	16.7
200	8.3	0.0
250	8.3	0.0

The results obtained from this work confirm that vitamin C supplementation to the diet of the laying hens under different temperatures counteracted the depression effect of the hest stress and improved the economic characters. Feed efficiency was increased in parallel relationship with an increase in egg production. Shell quality was significantly ipmroved. Mortality rate was reduced. This beneficial effect of vitamin C was acquired through its role in maintaining the normal physiological activities against the heat stress, as proved from the data of the different body reactions.

Adding ascorbic acid at rate of 250 ppm in the diet could be the recommended level during the laying period specially under hot environment.

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تأثير اعطاء فيتامين ج على التنظيم الحرارى للدجاج البياض

محمد جمال الدين قمر ، مختار عبد الفتاح قيقه ، أسامة عز الدين محمد
وعصمت عمر

قسم الانتاج الحيوانى ، كلية الزراعة ، جامعة القاهرة

استخدمت ٩٦ دجاجة بياضة لمدة ٣ شهور وقسمت الى مجموعتين الأولى خدمت كمجموعة مقارنة والثانية وضعت تحت ظروف حرارية بدرجة ٥٩٠ ف وقسمت كل مجموعة الى أربع مجاميع وأعطيت ٥٠ و١٠٠ و ٢٠٠ و ٢٥٠ جزء فى المليون من حامض الاسكوربيك . ووجد أن الدجاج الذى ربى تحت درجة حرارة مرتفعة أكل عليقة أقل وانخفض أيضا انتاج البيض لها وكذلك سمك القشرة وكالسيوم وفسفور الدم ووزن الغدة الدرقية . كذلك أدى ارتفاع الحرارة الى ارتفاع حرارة الجسم وسرعة التنفس وضغط الدم ونسبة النفوق وعند اضافة فيتامين ج لهذه المعاملة ذات درجة الحرارة المرتفعة أدى ذلك الى زيادة معدل تناول الغذاء وانتاج البيض وسمك القشرة وكالسيوم الدم وفى باقى الصفات وكان أحسن تأثير لفيتامين ج عند اعطاءه بنسبة ٢٥٠ جزء فى المليون وقد خفضت هذه النسبة التأثير الضار للحرارة البيئية .