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EFFECT OF SOME ENVIRONMENTAL FACTORS ON BODY WEIGHT AND GROWTH RATES AT DIFFERENT AGES IN TWO LOCAL STRAINS OF CHICKENS

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ABSTRACT: *The effect of different light colors (Incandescent, Fluorescent and Infrared light) and vitamin E supplementation on some parameters in Sinai and Norfa strains (body weight and growth rate) as well as the intensity of free radicals on the surface of the eggshell were studied. The numbers of treatments were 12 (6 treatments for each strain).*

The first group was exposed to incandescent light (control), the second was exposed to fluorescent light, and the third one was exposed to infrared light. All birds under light treatments were exposed to lighting period for 14 hours / day. Each group was divided into two subgroups, the first: vitamin E 1ml (20.000IU) added to one liter of their drinking water for 5 day/wk, whereas the second one consumes drink water without vitamin E.

Results indicated that incandescent light without vitamin E recorded the highest body weight of males in Sinai strain. While, it was infrared light without vitamin in female. On the other hand, with vitamin E supplementation, male chickens under infrared light were heavier body weight in Norfa strain. While, it was fluorescent light without vitamin in females.

Explore to incandescent light with vitamin E recorded the best growth rate of males and female in Sinai strain. On the other hand, without vitamin E supplementation, males under infrared light were higher growth rate in Norfa strain. The difference between light colors in growth rate were significant (P<0.05) during the period (16-20), but at (32-36) weeks of age it was highly significant (P<0.01).

Key words: *light colors, vitamin E, body weight, growth rate, local stains, chickens.*

INTRODUCTION

Light is an important aspect of an environment. Avian species as well as mammalian species respond to light energy in a variety of ways, including growth and reproductive performance. The color of light can have many different effects on behaviour growth and production in poultry. Birds sense light through their eyes (retinal photoreceptors) and through photosensitive cells in the brain (extra – retinal photoreceptors). Science long wavelength of light (towards red end of the spectrum) penetrate the skin and skull more efficiently than short wavelengths, it has been observed that growth and behaviour are linked to retinal photoreception (and shorter wavelengths) whereas the reproduction has been linked to extra-retinal photoreceptors. From these observations it has been reported than blue light has a calming effect on birds, however, red has been used to reduce cannibalism and feather picking. It has also been shown that blue-green light stimulates growth in chickens while orange-red stimulates reproduction. Birds have pigmented sensitivities of 415 nm, violet; 460 nm, blue; 510 nm, green, and 560 nm, yellow for young birds with: a peak at 580 nm, orange for adults, By, Andrews *and Zimmerman* (1990), Scheideler (1990) and Widowski *et al.,* (1992).

Growth in birds is affected by light spectra. Light of different wavelengths has varying stimulatory effects on the retina and can result in behavioral changes that will affect growth and development (Lewis and Morris, 2000). The oxidised α-tocopheroxyl radicals produced in this process may be recycled back to the active reduced form through reduction by other antioxidants, such as ascorbate, retinol or ubiquinol. However, the importance of the antioxidant properties of this molecule at the concentrations present in the body are not

clear and it is possible that the reason why vitamin E is required in the diet is unrelated to its ability to act as an antioxidant. Other forms of vitamin E have their own unique properties. For example, γ-tocopherol (also written as gamma-tocopherol) is a nucleophile that can react with electrophilic mutagens. [Herrera (2001), Packer, Lester (2001), Atkinson (2008) and Brigelius-Flohé (2009)].

MATERIALS AND METHODS

The present work was conducted at the Poultry Research Farm, Department of Poultry Production, Faculty of Agriculture, Minufiya University, Shibin El-Kom to study the effect of different light colors on body weight and growth rate in Sinai and Norfa strains.

Two hundred and forty females and males Norfa and Sinai strains aged 16 weeks (72 males and 168 females), were selected randomly. All experimental birds were kept and managed under the same conditions. Conventional diet and fresh clean water were available at all the experimental period. Routine veterinary care was conducted.

At 16 weeks of age, birds of each strain were divided into three comparable groups of 20 birds each (14 females and 6 males). The first group was exposed to incandescent light (control), the second one was exposed to fluorescent light, and the third one was exposed to infrared light. All birds under light treatments were exposed to the light regimes for 14 hours / day. Each group was divided into two subgroups, the first: vitamin E 1ml/L (20.000IU) added to one liter drink water for 5 day/wk, whereas the second one consume drink water without vitamin E. The number of experimental groups treatments were 12 (6 treatments for each strain). The treatments continued till the 40 weeks of age.

The birds were reared on the floor and supplied with incandescent, fluorescent, or infrared light colors under normal ambient temperature. Birds were kept in brooder pens, its area was 2X2 m^2 provided with a lamp hanged at middle of the pen. The height of all lamps was 1.5m from the floor for all treatments. Light intensity for infrared light was 15 lux, 7 lux for fluorescent light and 6 lux for incandescent light. Pens were light-proof by covering the windows with black sheets to prevent day light.

• Body Weight (B. W.):

The birds were weighed every 4-wks throughout the period of 16-40 weeks to the nearest gram.

• Growth rate (G.R.):

Growth rate was measured for each bird during the period of 40 weeks of age every 4-wks using the formula given by Brody (1945).

$$Growth\ rate = \frac{W_2 - W_1}{1/2(W_2 + W_1)} \times 100$$

Where: W1 = First weight
W_2 =Second weight

Data obtained were statistically analyzed using (SPSS, version 11.5 for windows). Duncan's multiple range was used for the multiple comparisons of means (Duncan, 1955).

RESULTS AND DISCUSSION

Body weight: The effect of different light colors under /or without vitamin E supplementation on body weight at different ages in Sinai (S) and Norfa (N) strain are reported in Tables (1, 2 and 3).

- Effect of light color treatment.

Table (1) illustrated that, the birds exposed to incandescent light (INC) were heavier than birds under infrared (IR) and fluorescent light(FL), were 698.5, 916.5, 1117.2, 1241.8, 1343.1, 1422.5 and 1518.1g at 16, 20, 24, 28, 32, 36 and 40 weeks of ages, respectively in Sinai (S) strain. Continues, Norfa (N) strain showed another trend, (FL) light had the highest body weight. However, (INC) light recorded the lowest body weight. These values were 1517.1and 1417.9g, respectively at 40 weeks of age (Table 1). This trend was in agreement with that obtained by Rozenboim *et al* ., (2004) and El-Fiky *et al.,* (2008) who found that turkeys exposed to incandescent light exhibited compensatory growth at latter age (Olanrewaju *et al.,* 2010).

Table 1

Table 2

Table 3

Table 3

However, differences between light color effects on body weights at different ages were not significant in Norfa strain. Similar insignificant effect of light colors was noticed Otten *et al.,* (1989) and Ahmad *et al.*, (2010).

- Effect of vitamin supplementation.

Data presented in Table (2) proved that the body weight in birds of both strains which fed diets without vitamin E supplementation were the highest in (S) and (N) strains. This trend was in agreement with that obtained by Malayglu *et al.*, (2009) and Ajakaiye *et al.*, (2011) on Hybrid White Leghorn (L33) layer hens.

However, differences between treatment effects on body weights at different ages were not significant. This trend was in agreement with that obtained by Lorenzani and Ruiz-Feria (2006), Kucukersan *et al.,* (2009) and Niu *et al.,* (2009).

- Effect of the interaction between light color and vitamin E supplements on B.W.

- In Sinai strain.

Data in (Table 3) illustrate the effect of light color and vitamin E on both sexes.

Birds exposed to incandescent light (INC) had the highest body weight at most ages in both sexes, under vitamin E. Where the results (in female with vitamin E supplementation), were 709.4, 898.1, 1029.6, 1135.1, 1235.2, 1282.0 and 1371.0 g at 16, 20, 24, 28, 32, 36 and 40 weeks of ages, respectively. The corresponding values in males with vitamin E supplementation were 752.0, 987.0, 1222.0, 1339.8, 1455.9, 1582.4 and 1691.6 g at the same ages, respectively .This trend was in agreement with that obtained by El-Fiky *et al.*, (2008) in turkey.

Without vitamin E supplementation (in males) at most ages, birds provided with (INC) light had the heaviest body weights (Table 3). Whereas, in females, birds exposed to (IR) light had the heaviest body weights at all studied ages (Table 3) were 786.8, 966.2, 1074.1, 1171.2, 1271.0, 1344.2 and 1423.4 (g) at 16, 20, 24, 28, 32, 36 and 40 weeks of ages, respectively. Some workers found that infrared light improved the body weight such as, El-Husseiny *et al.*, (2000) in broilers, El-Abd (2005) and El-Fiky *et al.*, (2008) in turkey.

According to sex effect, males were heavier than females and the difference was highly significant among all ages. These findings agree with those obtained by Hanafy *et al.*, (2009).

- In Norfa strain.

As shown in Table (3) female birds , which were exposed to (FL) light with vitamin E supplementation had heavier body weights at all ages than those under (IR) light , then birds with (INC) light ,these values were 1352.0,1197.0 and 1195.1g , respectively at 40 weeks of age.

Continues, male birds with vitamin E supplementation showed another trend, where males under infrared light were heavier significantly than males under fluorescent light. The values were 1823.6g with (IR) light, 1640.9g with (FL) light and 1429.5g with (INC) light. This different trend may be due to sex* light color interaction within each strain. This finding agrees with the result of El-Husseiny *et al.* (2000), El-Abd (2005), El-Slamony *et al.,* (2007) and El- Fiky *et al.*, (2008). In while, Lewis *et al.,* (2007) and Ahmad *et al.,* (2010).

Without vitamin E supplementation, female birds under (FL) light were heavier than those under (INC) light and under (IR) light the mean values were 1406.0, 1371.1 and 1286.1, respectively at 40 weeks of age and the difference was significant. But in males, birds under (INC) light had higher body weight than those under (FL) light and latterly birds under (IR) light .the mean values were 1675.9, 1669.2 and 1650.3 g, respectively at 40 weeks of age.

In both strains, sex difference was significantly affected body weights at all ages. The overall means of males were 723.7, 934.7, 1149.9, 1280.2, 1396.2, 1532.7 and 1630.6 at 16, 20, 24, 28, 32, 36 and 40 weeks of age for (S) strain and 721.6, 931.9, 1144.6, 1297.6, 1398.8, 1533.8 and 1648.2 in (N) strain at the

same ages, respectively. The corresponding values for females in (S) strain were 661,845.4, 997.8, 1103.6, 1190.9, 1259.6 and1338 at16, 20, 24, 28, 32, 36 and 40 weeks of age and (617.2, 788.6, 958.6, 1067.4, 1144, 1203.9 and 1301.2) at the same ages in (N) strain.

This finding agrees with the result of Kosba *et al.,* (2002). Meanwhile, Ben Naser (2007) reported that the overall means of BWm in Norfa pullets selected for heavy and light body weights after two generations were 1178.6, 1339.4 and 1258.7g in low, high and control lines, respectively.

In Sinai strain(S), Arad and marder (1982) reported that means of mature body weight of Sinai fowl was 1260g. soltan *et al* ., (1985) found an average mature body weight of 1400 g.

Data illustrated that moderate highly significant correlation coefficients were calculated between body weights at different ages. However, it is clear that the highest values were obtained between closed ages.

Growthrate:

Data concerning the effect of light color under /or without vitamin E supplementation on growth rate in Sinai (S) and Norfa (N) strain are presented in Tables (4, 5 and 6).

- Effect of light color treatment.

The birds exposed to infrared (IR) light were highest growth rate than birds under incandescent (INC) and fluorescent (FL) light, these values were 6.5, 6.4 and 5.2%, respectively at 36-40 weeks of age in (S) strain. Continues, (N) strain showed another trend, where birds under (FL) light had the highest growth rate at most ages than those under (IR) light, then birds with (INC) light ,these values were 8.6, 7.7 and 6.3% , respectively at 36-40 weeks of age (Table 4). This trend was in agreement with that obtained by Rozenboim *et al*., (1999) and El-Husseiny *et al*., (2000) in broiler chickens.

However, the difference between light colors affects at all of studied ages on growth rate were not significant. Similar insignificant effect of light colors was noticed by Hulan and Proudfoot (1987), Lewis *et al.,* (2007) and Ahmad *et al.,* (2010). This effect could be due to different wavelengths of light which has varying stimulatory effects on the retina and can result in behavioural changes that will affect growth and development (Lewis and Morris, 2000).

- Effect of vitamin supplementation.

Data presented in Table (5) proved that the body weight in birds which treated with vitamin E were the highest in (S) strain. The mean values were 24.7, 19.8, 10.7, 8.1, 8.4 and6.1 % at 16-20, 20-24, 24-28, 28-32, 32-36 and 36-40 weeks of age, respectively. While in (N) strain, without vitamin E were higher growth rate at most ages. The mean values were 24.9, 19.2, 12.9, 7.9, 8.0 and 8.3 % at 16-20, 20-24, 24-28, 28-32-32-36 and 36-40 weeks of ages, respectively. This trend was in agreement with that obtained by Ajakaiye *et al.,* (2011) and Tavárez *et al.,* (2012). These results indicated that antioxidant properties may explain the weight gain improving.

However, differences between treatment effects on growth rate at different ages were not significant. This trend was in agreement with that obtained by Avila-Ramos *et al*., (2012) on broilers.

- Effect of the interaction between light color and vitamin E supplements.

- In Sinai strain.

Data in (Table 6) illustrate the effect of light color under vitamin E supplementation in both sexes among Sinai (S) strain.

It was clear that, birds exposed to infrared (IR) light had the highest growth rate at most ages. Where its female averages were 27.3, 20.6, 10.4, 8.0, 6.4, and 8.0% at 16-20, 20-24, 24-28, 28-32, 32-36 and 36-40 weeks of ages, respectively. Also, the corresponding values in males under the same light were 20.3, 23.3, 13.7, 9.3, 16.6and 6.3 at the previous ages, respectively .This trend was in agreement with Rearing laying hens under pure monochromatic red light at 0.01 W/m^2 caused a significant reduction in feed intake due to a reduction in physical activity (Rozenboim *et al.,* 1999) and El-Husseiny *et al.;* (2000) in broilers, El-Abd (2005) and Hanafy *et al.,* (2009).

Table 4

Table 5

Table 6

Table 6

vitamin E supplementation (in males) at most ages, birds provided with incandescent (INC) light had the greatest growth rate (Table 6). The same trend was noticed in females, these values were 28.3, 20.1, 12.9, 7.8, 4.7(%) and 5.7 at 16-20, 20-24, 24-28, 28-32, 32-36 and 36-40 weeks of ages, respectively. This trend was in agreement with that obtained by El-Fiky *et al.,* (2008) in turkey. This effect could be due to different wavelengths of light which has varying stimulatory effects on the retina and can result in behavioural changes that will affect growth and development (Lewis and Morris, 2000).

- In Norfa strain

As obtained in Table(6) female birds , which were exposed to (FL) light with vitamin E supplementation had greater growth rate at most of ages than those under (INC) light, then birds with (IR) light ,these values were 7.1, 6.8 and 4.8% , respectively at 36-40 weeks of age.

Also, male birds with vitamin E supplementation showed the similar trend, where males under (FL) light were growed faster than males under (IR) light and (INC) light. The values were 9.1, 7.3 and 6.0 %, respectively at 36-40 weeks of age.

Without vitamin E supplementation, female fowls under (FL) light were greater than those under (IR) light and under (INC) light at 16-20 wk, 24-28 wk and 36-40 wk. The mean values were 26.2, 15.6 and 9.9, respectively .While in males, birds under (IR) light had higher growth rate at all ages than those under (FL) and (INC) light. The mean values were 26.9, 23.4, 13.8, 10.3, 20.7 and 9.3 at 16-20, 20-24, 24-28, 28-32, 32-36 and 36-40 weeks of age. This trend was in agreement with El-Husseiny *et al.,* (2000), El-Abd (2005), El-Slamony *et al.,* (2007) and El-Fiky *et al.,* (2008).

In both strains, sex difference was not significantly affected growth rate during all periods of age. The overall means of males in (S) strain, these values were 25.5, 20.7, 10.8, 8.7, 9.4 and 6.2 at 16-20, 20-24, 24-28, 28-32, 32-36 and 36-40 weeks of age, respectively. These values were 25.6, 20.7, 12.7, 7.7, 9.5 and 7.3 in (N) strain. The corresponding values for females in (S) strain were 25.0,16.7, 10.3, 7.6, 5.6 and 5.9 at 16-20, 20-24, 24-28, 28-32, 32-36 and 36-40 weeks of ages and 24.4, 19.4, 10.7, 6.9, 5.1 and 7.8 at the same ages in (N) strain .This finding agrees with the result of Khalil *et al.,* (2008) and Hanafy *et al.,* (2009).

Data illustrated that low negative and not significant correlation coefficients were calculated between growth rates at different ages.

Also, negative and insignificant correlation coefficients were observed between growth rates at most of ages.

Soltan (1991) noticed similar trend in Sinai fowls, also (1992) in Baladi fowls and El-Husseiny *et al.,* (2000) in broilers.

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تأثير بعض العوامل البيئية على وزن الجسم ومعدل النموفي الأعمار المختلفة في سلالتين محليتين من الدجاج

محمد السيد سلطان ، أحمد عبدالوهاب عنب ، عبدالمنعم عبدالحليم الفقى ، دينا عبدالفتاح سليم

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الملخص العربي

أجريت هذه الدراسة بمزرعة بحوث الدواجن، قسم إنتاج الدواجن ، كلية الزراعة بشبين الكوم، جامعة المنوفية. استخدم في هذه التجربة ٢٤٠طائر ذكور وإناث من سلالة سيناء و نورفا عمر ١٦ اسبوعا(٧٢ ديك و١٦٨ انثي)،اختيرت عشوائيا.

قسمت الطيور الي ستة مجموعات ، و كل سلالة تحتوي علي ثلاثة مجموعات كالآتي:

المجموعة الاولي : عرضت الطيور للون الأبيض (الفلورسنت) و المجموعة الثانية : عرضت الطيور للأشعة التحت الحمراء و المجموعة الثالثة : عرضت الطيور للضوء الأصفر العادى .

كل مجموعة احتوت علي ٢٠طائر، وقسمت كل مجموعة الي تحت مجموعتين حيث عوملت الاولي بفيتامين هـ بتركيز ٢٠ ألف وحدة دولية بمعدل ١ مل / لتر ماء لمدة ٥ أيام في الاسبوع والتحت مجموعة الاخري عوملت

بالفيتامين تحت ظروف الاضاءة المختلفة أي استخدمت ٦ معاملات في كل سلالة أي (١٢ معاملة) في كلا السلالتين.

وأجريت التجربة بهدف دراسة تأثير ألوان الاضاءة المختلفة الضوء الأبيض (الفلورسنت) و الضوء الأصفر العادي والأشعة تحت حمراء وتأثير اضافة فيتامين هـ علي بعض الصفات الفسيولوجية في سلالتي نورفا وسيناء علي:- وزن الجسم و معدل النمو .

تم تلخيص النتائج المتحصل عليها كما يلي:-

وجود فروق غير معنوية بين الإضاءات المختلفة علي أوزان الجسم في الأعمار المختلفة في سلالة النورفا.

كانت الطيور المعرضة للضوء الأصفر العادي مع عدم إضافة فيتامين هـ أعلي في أوزان الجسم من الذكور ،بينما كانت الإناث المعرضة للضوء الأحمر مع عدم إضافة فيتامين هـ أعلي وزناً. ومن جهة اخري كانت الذكور المعرضة للضوء الأحمر مع إضافة فيتامين هـ أعلي وزناً ،بينما الإناث المعرضة للضوء الأبيض كانت أعلي وزناً . كان تأثير الجنس علي وزن الجسم معنوي جداً (باحتمال ٠.٠١).

كان تأثير التداخل بين (ألوان الإضاءة والسلالة) ،(ألوان الإضاءة وإضافة أو عدم إضافة فيتامين هـ والسلالة) عالي المعنوية (باحتمال ٠.٠١) علي أوزان الجسم في الأعمار المختلفة.

كانت معاملات الارتباط بين أوزان الجسم في الأعمار المختلفة غالبا موجبة وعالية المعنوية.

أوضحت النتائج أن ذكور وإناث سلالة سيناء المعرضة للضوء الأبيض (الفلورسنت) مع إضافة فيتامين هـ كانت الأفضل في معدل النمو ، بينما في حالة عدم إضافة فيتامين هـ كانت الذكور المعرضة للضوء الأحمر أعلي في معدلات النمو، بينما الإناث كانت أعلي تحت الضوء الأبيض (الفلورسنت) في سلاله نورفا.

أوضحت النتائج أن تأثير الجنس علي معدل النمو كان غيرمعنوي في معظم فترات النمو، بينما كان عالي المعنوية (باحتمال ٠.٠١) في الفترة بين ٣٦-٣٢ اسبوع.

كانت معاملا ت الارتباط بين معدلات النمو في الفترات المختلفة سالب.

Table (1): Body weight (g) at different ages ($\bar{X}+S.E$) in Sinai and Norfa strains under different light color treatments.

Strain	Light color	Body weight						
		16 WK	20 WK	24 WK	28 WK	32 WK	36 WK	40 WK
Sinai	Incandescent light	698.5±16.19^{ab}	916.5±17.07 ^{a}	1117.2±21.06^{a}	1241.8±21.33 ^{a}	1343.1±22.68 ^{a}	1422.5±23.80 ^{a}	1518.1±24.47 ^{a}
	Fluorescent light	658.6±17.20^{b}	839.5±18.14 ^{b}	1006.1±22.38^{b}	1112.0±22.67 ^{b}	1210.0±24.10 ^{b}	1315.1±25.29 ^{b}	1386.5±26.00 ^{b}
	Infrared light	719.9±23.69^{a}	914.1±24.98 ^{a}	1098.4±30.81^{a}	1221.9±31.21 ^{a}	1327.5±33.18 ^{a}	1450.8±34.82 ^{a}	1548.4±35.80 ^{a}
Norfa	Incandescent light	659.2±17.67^{b}	863.6±18.63	1040.7±22.98	1161.6±23.28	1254.1±24.75	1336.2±25.97	1417.9±26.70
	Fluorescent light	689.3±19.64^{a}	858.4±20.72	1053.2±25.55	1213.3±25.88	1309.2±27.51	1393.2±28.88	1517.1±29.69
	Infrared light	659.7±19.95^{b}	858.9±21.04	1060.9±25.95	1172.7±26.29	1250.9±27.95	1377.0±29.33	1489.2±30.16

a,b,c Means within the same column and the same treatment factores carry different small superscripts are significant at level $P \leq 0.05$,

Table (2): Body weight (g) at different ages ($\bar{X}+S.E$) in Sinai and Norfa strains under different vitamin E supplementations.

Strain	treatments	Body weight						
		16 WK	20 WK	24 WK	28 WK	32 WK	36 WK	40 WK
Sinai	Vitamin E	673.3±17.66	861.6±18.62	1051.2±22.97	1168.9±23.27	1268.2±24.73	1384.1±25.96	1472.2±26.69
	Without vitamin E	711.3±13.62	918.5±14.37	1096.6±17.72	1214.9±17.95	1319.0±19.08	1408.2±20.02	1496.5±20.58
Norfa	Vitamin E	665.7±15.24	858.6±16.07	1059.1±19.82	1175.4±20.08	1255.6±21.34	1343.0±22.40	1439.7±23.03
	Without vitamin E	673.0±15.97	862.0±16.84	1044.1±20.77	1189.7±21.04	1287.2±22.37	1394.6±23.48	1509.8±24.13

Table (3): Body weight (g) at different ages ($\bar{X} + S.E$) in Norfa and Sinai strains under different treatments (light color and vitamin E supplements).

Strain	treatment	Sex	Light color	Body weight						
				16 WK	20 WK	24 WK	28 WK	32 WK	36 WK	40 WK
Sinai	Vitamin E	Female	Incandescent light	709.4±29.6^{a}	898.1±31.2 ^{a}	1029.6±38.4	1135.1±38.9	1235.2±41.4	1282.0±43.5 ^{a}	1371.0±44.7 ^{a}
			Fluorescent light	613.9±24.7^{b}	778.8±26.1 ^{b}	955.0±32.2	1050.2±32.6	1105.4±34.6	1154.5±36.4 ^{b}	1199.8±37.4 ^{b}
			Infrared light	617.3±29.6^{ab}	812.6±31.2^{ab}	999.5±38.4	1107.3±38.9	1200.0±41.4	1278.0±43.5 ^{a}	1385.0±44.7 ^{a}
			Overall	646.9	829.9	994.7	1097.5	1180.2	1238.2	1318.6
		Male	Incandescent light	752.0±35.0 ^{a}	987.0±36.9 ^{a}	1222.0±45.5 ^{a}	1339.8±46.1^{a}	1455.9±49.0 ^{A}	1582.4±51.4 ^{B}	1691.6±52.9 ^{B}
			Fluorescent light	628.7±39.1 ^{b}	812.4±41.2 ^{b}	988.7±50.9 ^{b}	1105.5±51.5^{b}	1212.9±54.8 ^{B}	1355.3±57.5 ^{B}	1426.4±59.1 ^{B}
			Infrared light	718.6±78.2 ^{a}	880.6±82.5 ^{a}	1112.3±101.7^{a}	1275.7±103.0^{ab}	1399.6±109.5^{AB}	1652.2±115.0^{A}	1759.2±118.2^{A}
			Overall	699.8	893.3	1107.6	1240.3	1356.1	1530.0	1625.7
	Without vitamin E	Female	Incandescent light	595.3±29.6 ^{b}	791.7±31.2 ^{b}	970.8±38.4 ^{b}	1102.2±38.9	1193.5±41.4 ^{ab}	1250.4±43.5	1325.0±44.7
			Fluorescent light	643.2±23.6^{ab}	824.7±24.9^{ab}	957.9±30.7 ^{b}	1055.7±31.1	1139.6±33.0 ^{b}	1248.3±34.7	1323.6±35.6
			Infrared light	786.8±27.6 ^{a}	966.2±29.2 ^{a}	1074.1±36.0 ^{a}	1171.2±36.4	1271.6±38.7 ^{a}	1344.2±40.6	1423.4±41.8
			Overall	675.1	860.9	1000.9	1109.7	1201.6	1281.0	1357.4
		Male	Incandescent light	737.1±35.0	989.4±36.9 ^{B}	1246.3±45.5 ^{a}	1390.1±46.1 ^{A}	1488.0±49.0 ^{a}	1575.3±51.4 ^{A}	1684.8±52.9
			Fluorescent light	748.6±45.2	941.9±47.6^{C}	1122.8±58.7 ^{b}	1236.7±59.5 ^{B}	1382.3±63.2 ^{b}	1502.4±66.4 ^{B}	1596.0±68.2
			Infrared light	757.0±35.0	997.0±36.9 ^{A}	1207.6±45.5 ^{ab}	1333.3±46.1 ^{AB}	1438.9±49.0 ^{ab}	1528.6±51.4^{AB}	1625.9±52.9
			Overall	747.6	976.1	1192.2	1320.0	1436.4	1535.4	1635.6

a,b,c Means within the same column and the same treatment factores carry different small superscripts are significant at level $P \leq 0.05$,
A,B,C Means within the same column and the same treatment factores carry different capital superscripts are significant at $P \leq 0.01$

Table (3): Continued

Strain	treatment	Sex	Light color	Body weight						
				16 WK	20 WK	24 WK	28 WK	32 WK	36 WK	40 WK
Norfa	Vitamin E	Female	Incandescent light	559.8±39.1 ^{b}	734.9±41.2	890.0±50.9	990.6±51.5	1062.7±54.8	1117.8±57.5 ^{b}	1195.1±59.1 ^{b}
			Fluorescent light	653.2±35.0 ^{a}	795.3±36.9	1006.5±45.5	1117.5±46.1	1203.0±49.0	1257.8±51.4 ^{a}	1352.1±52.9 ^{a}
			Infrared light	605.1±31.9 ^{b}	776.8±33.7	942.1±41.5	1017.2±42.1	1085.6±44.7	1140.3±46.9 ^{b}	1197.0±48.2 ^{b}
			Overall	606.1	769.0	946.2	1041.7	1117.1	1172.0	1248.1
		Male	Incandescent light	630.4±31.9 ^{c}	857.0±33.7 ^{b}	1060.5±41.5 ^{b}	1155.1±42.1 ^{b}	1239.1±44.7 ^{c}	1347.3±46.9 ^{c}	1429.5±48.2 ^{c}
			Fluorescent light	695.7±45.2 ^{b}	872.3±47.6 ^{b}	1091.3±58.7 ^{b}	1245.1±59.5 ^{b}	1358.9±63.2 ^{b}	1499.5±66.4 ^{b}	1640.9±68.2 ^{b}
			Infrared light	850.2±39.1 ^{a}	1115.2±41.2 ^{a}	1364.4±50.9 ^{a}	1527.0±51.5 ^{a}	1584.3±54.8 ^{a}	1695.4±57.5 ^{a}	1823.6±59.1 ^{a}
			Overall	725.4	948.2	1172.1	1309.1	1394.1	1514.1	1631.3
	Without vitamin E	Female	Incandescent light	635.0±35.0 ^{b}	801.0±36.9 ^{b}	963.0±45.5	1094.7±46.1	1184.3±49.0 ^{ab}	1261.4±51.4 ^{ab}	1371.1±52.9 ^{b}
			Fluorescent light	644.9±29.6 ^{a}	839.2±31.2 ^{a}	974.5±38.4	1142.1±38.9	1216.0±41.4 ^{a}	1276.6±43.5 ^{a}	1406.0±44.7 ^{a}
			Infrared light	604.8±27.6 ^{b}	784.8±29.2 ^{b}	975.4±36.0	1042.8±36.4	1112.5±38.7 ^{b}	1169.4±40.6 ^{b}	1286.1±41.8 ^{b}
			Overall	628.3	808.3	971.0	1093.2	1170.9	1235.8	1354.4
		Male	Incandescent light	811.6±35.0 ^{a}	1061.6±36.9 ^{a}	1249.2±45.5 ^{a}	1406.3±46.1 ^{a}	1530.4±49.0 ^{a}	1618.3±51.4	1675.9±52.9
			Fluorescent light	763.3±45.2 ^{a}	926.9±47.6 ^{a}	1140.5±58.7^{ab}	1348.4±59.5 ^{a}	1459.0±63.2^{ab}	1539.1±66.4	1669.2±68.2
			Infrared light	578.6±55.3 ^{b}	758.6±58.3 ^{b}	961.8±71.9 ^{b}	1103.9±72.9 ^{b}	1221.3±77.5 ^{b}	1503.0±81.3	1650.3±83.6
			Overall	717.8	915.7	1117.2	1286.2	1403.5	1553.5	1665.1

a,b,c Means within the same column and the same treatment factores carry different small superscripts are significant at level $P \leq 0.05$,

Table (4): Growth rates (%) at different periods ($\bar{X}+S.E$) in Sinai and Norfa strains under different light color treatments.

Strain	Light color	Growth rate (%)					
		16-20 WK	20-24 WK	24-28 WK	28-32 WK	32-36 WK	36-40 WK
Sinai	Incandescent light	27.4±1.43	19.4±1.26	10.8±1.20	7.9±0.82	5.6±0.77 [b]	6.4±0.75
	Fluorescent light	24.1±1.51	18.1±1.34	10.0±1.28	8.3±0.87	8.2±0.82 [ab]	5.2±0.80
	Infrared light	24.1±2.09	18.4±1.85	10.7±1.76	8.3±1.20	8.6±1.12 [a]	6.5±1.10
Norfa	Incandescent light	26.6±1.56 [a]	18.9±1.38 [b]	10.8±1.31	7.6±0.90	6.3±0.84	6.3±0.82
	Fluorescent light	22.2±1.73 [b]	20.3±1.53 [ab]	14.2±1.46	7.6±1.00	6.1±0.93	8.6±0.92
	Infrared light	26.2±1.76 [a]	21.0±1.55 [a]	9.9±1.48	6.7±1.01	9.4±0.95	7.7±0.93

a,b,c Means within the same column and the same treatment factores carry different small superscripts are significant at level $P \leq 0.05$,

Table (5): Growth rates (%) at different periods ($\bar{X}+S.E$) in Sinai and Norfa strains under treatments vitamin E supplementations.

Strain	Treatment	Growth rate (%)					
		16-20 WK	20-24 WK	24-28 WK	28-32 WK	32-36 WK	36-40 WK
Sinai	Vitamin E	24.7±1.55	19.8±1.38	10.7±1.31	8.1±0.90	8.4±0.84	6.1±0.82
	Without vitamin E	25.7±1.20	17.5±1.06	10.4±1.01	8.2±0.69	6.6±0.65	6.0±0.64
Norfa	Vitamin E	25.1±1.34	20.9±1.19	10.4±1.13	6.7±0.77	6.6±0.72	6.9±0.71
	Without vitamin E	24.9±1.41	19.2±1.24	12.9±1.19	7.9±0.81	8.0±0.76	8.3±0.74

Table (6): Growth rates (%) at different periods ($\bar{X}+S.E$) in Sinai and Norfa strains under different treatments (light color and vitamin E supplements).

Strain	Treatment	Sex	Light color	Growth rate (%)					
				16-20 WK	20-24 WK	24-28 WK	28-32 WK	32-36 WK	36-40 WK
Sinai	Vitamin E	Female	Incandescent light	24.6±2.6	13.5±2.3 ^{b}	10.1±2.2	8.6±1.5	3.8±1.4	6.5±1.4 ^{ab}
			Fluorescent light	23.4±2.2	20.6±1.9 ^{a}	9.5±1.8	5.1±1.3	4.4±1.2	3.9±1.2 ^{b}
			Infrared light	27.3±2.6	20.6±2.3 ^{ab}	10.4±2.2	8.0±1.5	6.4±1.4	8.0±1.4 ^{a}
			Overall	25.1	18.2	10.0	7.2	4.8	6.1
		Male	Incandescent light	27.1±3.1 ^{a}	21.3±2.7	9.2±2.6	8.3±1.8	8.3±1.7	6.7±1.6
			Fluorescent light	25.4±3.4 ^{ab}	19.7±3.0	11.1±2.9	9.3±2.0	11.1±1.9	5.2±1.8
			Infrared light	20.3±6.9 ^{b}	23.3±6.1	13.7±5.8	9.3±4.0	16.6±3.7	6.3±3.6
			Overall	24.3	21.4	11.3	8.9	12.0	6.1
	Without vitamin E	Female	Incandescent light	28.3±2.6 ^{a}	20.1±2.3 ^{A}	12.9±2.2	7.8±1.5	4.7±1.4 ^{b}	5.7±1.4
			Fluorescent light	24.7±2.1 ^{ab}	14.6±1.8 ^{A}	9.8±1.8	7.6±1.2	8.9±1.1 ^{a}	5.8±1.1
			Infrared light	21.4±2.4 ^{b}	10.6±2.2 ^{B}	8.9±2.1	8.3±1.4	5.5±1.3 ^{ab}	5.7±1.3
			Overall	24.8	15.1	10.5	7.9	6.4	5.7
		Male	Incandescent light	29.5±3.1 ^{a}	22.8±2.7	11.1±2.6 ^{A}	6.8±1.8	5.7±1.7	6.7±1.6
			Fluorescent light	22.8±4.0 ^{b}	17.6±3.5	9.7±3.4 ^{B}	11.1±2.3	8.3±2.1	6.0±2.1
			Infrared light	27.4±3.1 ^{ab}	19.1±2.7	9.7±2.6 ^{B}	7.6±1.8	6.1±1.7	6.2±1.6
			Overall	26.6	19.9	10.2	8.5	6.7	6.3

a,b,c Means within the same column and the same treatment factores carry different small superscripts are significant at level $P \leq 0.05$,
A,B,C Means within the same column and the same treatment factores carry different capital superscripts are significant at $P \leq 0.01$

Table (6): Continued

Strain	Treatment	Sex	Light color	Growth rate (%)					
				16-20 WK	20-24 WK	24-28 WK	28-32 WK	32-36 WK	36-40 WK
Norfa	Vitamin E	Female	Incandescent light	26.6±3.4	19.1±3.0	10.8±2.9	7.0±2.0	5.1±1.9	6.8±1.8
			Fluorescent light	19.6±3.1	23.4±2.7	10.7±2.6	7.3±1.8	4.4±1.7	7.1±1.6
			Infrared light	24.9±2.8	19.0±2.5	7.7±2.4	6.6±1.6	5.0±1.5	4.8±1.5
			Overall	23.7	20.5	9.8	7.0	4.8	6.2
		Male	Incandescent light	30.1±2.8 ^{a}	21.4±2.5 ^{AB}	8.4±2.4 ^{b}	7.2±1.6	8.4±1.5	6.0±1.5
			Fluorescent light	22.7±4.0 ^{b}	22.5±3.5 ^{A}	13.2±3.4 ^{a}	8.7±2.3	9.8±2.1	9.1±2.1
			Infrared light	27.0±3.4 ^{ab}	20.0±3.0 ^{B}	11.4±2.9 ^{ab}	3.7±2.0	6.8±1.9	7.3±1.8
			Overall	26.6	21.3	11.0	6.5	8.3	7.5
	Without vitamin E	Female	Incandescent light	23.3±3.1	18.5±2.7 ^{ab}	12.4±2.6 ^{a}	7.8±1.8	6.2±1.7	8.9±1.6
			Fluorescent light	26.2±2.6	14.9±2.3 ^{b}	15.6±2.2 ^{a}	6.3±1.5	4.7±1.4	9.9±1.4
			Infrared light	25.9±2.4	21.4±2.2 ^{a}	6.5±2.1 ^{b}	6.5±1.4	5.1±1.3	9.4±1.3
			Overall	25.1	18.3	11.5	6.8	5.3	9.4
		Male	Incandescent light	26.5±3.1	16.5±2.7	11.7±2.6	8.5±1.8	5.7±1.7 ^{b}	3.5±1.6
			Fluorescent light	20.4±4.0	20.4±3.5	17.2±3.4	8.0±2.3	5.4±2.1 ^{b}	8.5±2.1
			Infrared light	26.9±4.9	23.4±4.3	13.8±4.1	10.3±2.8	20.7±2.6 ^{a}	9.3±2.6
			Overall	24.6	20.1	14.3	8.9	10.6	7.1

a,b,c Means within the same column and the same treatment factores carry different small superscripts are significant at level P≤ 0.05,
A,B,C Means within the same column and the same treatment factores carry different capital superscripts are significant at P≤ 0.01