Journal of Sohag Agriscience (JSAS) 2023, 8(2):140-146

ISSN 2309-1110
https://jsasj.journals.ekb.eg
JSAS 2023; 8(2): 140-146

Received: 13-09-2023
Accepted: 24-09-2023

Ahmed A. Abuoghaba
Zienhom. S. H. Ismail
Heba Gamal

Poultry Sciences Department
Faculty of Agriculture
Sohag University
Sohag
82524
Egypt

Hamada A. M. Elwan

Animal Production Department
Faculty of Agriculture
Minia University
Minia
Egypt

Corresponding author:
Heba Gamal
heba.gamal.96hg@gmail.com

Impact of short and long-term thermal manipulation during early embryogenesis on productive performance of quails

Ahmed A. Abuoghaba, Zienhom. S. H. Ismail, Hamada A. M. Elwan and Heba Gamal

Abstract

This study was conducted to evaluate the impact of short and long-term thermal manipulation during early embryogenesis (E4-6d) on the productive performance of quails. A total of 600 quail eggs were divided into 4 equal groups (4 groups × 5 replicates × 30 eggs). In the first group (control), eggs were incubated at 37.5 °C & 55–60% RH from day 0 up to 14 days of incubation. In the second group (short thermal manipulation/ STM), eggs were daily exposed to 39.0 °C and 55-60% for three successive days (4-6 d) during early embryogenesis for 3 hours. In the third (middle thermal manipulation/MSM), eggs were daily exposed to 39.0 °C and 55-60% for 3 successive days (4-6 d) during early embryogenesis for 6 hours. In the fourth (long thermal manipulation/LSM), eggs were daily exposed to 39.0 °C and 55-60% for 3 successive days (4-6 d) during early embryogenesis for 12 hours.

The achieved findings could be summarized as follows:

- The body weight at 35 and 42 days of age for chicks produced from eggs in the 4th group was significantly decreased compared with those of the 1st (control), 2nd (STM), and 3rd (MSM) groups.
- The obtained results showed that the daily and total weight gain during (28–24 d) and (1–42 d) for chicks produced from eggs in the 4th group) were significantly decreased compared with those in the 1st (control), 2nd (STM), and 3rd (MTM) groups.
- The daily feed consumption for quail chicks in the 4th group during 1–14, 14–28, and 28–42 days of age was insignificantly decreased as compared with those in the 1st (control), 2nd (STM), and 3rd (MTM) groups.
- The total feed intake for quail chicks in the 4th (LTM) group during 1-42 days of age was significantly decreased as compared with those in the 1st (control), 2nd (STM), and 3rd (MTM) groups.
- The obtained results showed that the daily and total feed conversion ratios in different groups were insignificantly influenced.

It is suggested that short (3 hours/d) and middle (6 hours/d) thermal manipulations be utilized due to their beneficial impact on the growth of quail birds during the growing period.

Keywords:
Short, long thermal manipulation, productive performance, quails

INTRODUCTION

Quail (Coturnix coturnix) farms produce meat and eggs besides other products (Runjai'c-Anti'c et al., 2010). They are frequently utilized as a tool in extensive genetic studies since they are simple to handle as laboratory animals (Nowaczewski *et al.,* 2010). Quail as well as chicken embryonic development, hatching, and survival rates are affected by a number of variables, including how the egg is stored and turned, as well as temperature, relative humidity, and ventilation (Romao *et al.,* 2009). Quail embryos are homeotherms and require optimal incubation temperatures for their development, which range from 37.5 to 37.8 °C (Romao *et al.,* 2009), to achieve maximum growth and consequently commercial production for birds (Christensen *et al.,* 2003 and Boleli *et al.,* 2016). Since the eggshell is considered a thermal barrier that influences the actual embryo temperature, eggshell temperature during incubation phase plays a significant role in embryo development and the chicken performance (Molenaar *et al.,* 2008). This effect is influenced by the pattern of airflow around the egg. If the temperature of the embryos is lower than the temperature of the egg, heat transfer from the incubators surrounding air to the embryos occurs in the early phases of embryonic development (Leksrisompong *et al.,* 2007). Short-term and long-term effects can be categorized by changes in incubation temperature or the duration of thermal manipulation. The heat loss mechanism in chick embryos was found to be induced by a temporary increase in the incubation temperature (Holland *et al.,* 1997). The results of Piestun *et al.,* (2008) illustrated that the hatching eggs exposed to continuous thermal manipulation (39.5 °C) during early embryogenesis (7–16 d) had significantly lower post-hatching growth performance than eggs exposed to 39.5 °C for 12 hours per day. The results of Abuoghaba *et al.,* (2023) showed that the body weight of hatched quail chicks produced from eggs incubated at a normal temperature of 37.5 °C was significantly ($P \leq 0.01$) larger than those subjected to a high (39.0 °C) incubation temperature. Therefore, the aim of the study was to evaluate the effects of short- and long-term thermal manipulation throughout early embryogenesis (E4-6d) on the productive performance of quail.

MATERIALS AND METHODS

This study was conducted from November 2022 to January 2023 at an experimental poultry farm, Poultry Production Department, Faculty of Agriculture, Sohag University, Sohag, Egypt. It designed to study the impact of thermal manipulations during early (E4-6d) incubation phase on the productive performance of quail chicks.

Eggs and thermal manipulations

A total of 600 quail eggs were classified to four groups (4 groups × 5 replicates × 30 eggs). In the 1st group, eggs were incubated from 0 to 14 days at 37.5°C and 55–60% RH and considered as control. The eggs in the 2nd group (short thermal manipulation; STM), 3rd group (middle thermal manipulation; MTM), and 4th group (long thermal manipulation; LSM) were manipulated to daily treatments of 39.0°C and 55–60 RH% for 3, 6, and 12 hours, respectively, throughout the early embryogenesis phase (4-6 days). Until the experiment ended, quail chicks were exposed daily to light (30-40 lux/m^2) for 23 hours. For the first 15 days of the growing period, newly chicks were kept in wooden floor pens as well as they were housed in battery cages from days 16 to 42d of age. All quail chicks were fed a diet that contained 22.52% CP and 12.78 MJ kg of feed from hatching to day 42. Throughout the experiment, feed and clean drinking water were freely available.

Traits under study:

Growth performance

The live body weight of all chicks was measured at hatch, 7, 14, 21, 28, 35 and 42 days. The weight gain (g) for chicks was calculated using the following formula (final weight – (Initial weight)/days. The feed intake was weekly recorded allover experimental period, and the feed conversion ratio (g feed/g meat) was calculated by dividing feed intake by chick weight gain (g). The age at laying of the first egg (day) was calculated. Also, the first egg weight in different groups were weighed and recorded.

Statistical analysis

A general linear model (GLM) was performed in SAS (2004) using this model: Yijk = μ + Ti + eijk, where Yijk is an observation, μ is the overall mean, Ti is the effect of thermal manipulations (i = 1, 2, 3, 4), and eijk is the random error. Differences between least squares means (LSM) were tested for $P \leq 0.05$ using Duncan, (1955) test.

RESULTS AND CONCLUSIONS

Impact of thermal manipulations on the productive performance of quails

1. Body weight:

Table 1 shows the impact of thermal manipulations on the body weight and body weight gain in quail chicks. The body weight of quails in the 4th group decreased significantly than that of the 1st (control), 2nd (STM), and 3rd (MSM) groups at 35 and 42 days of age. The significant decrease in chick weight under high incubation temperatures may be caused by the reduced chick metabolic rates and embryos when the eggshell temperature rises during early incubation **(Janke *et al.*, 2002)**. These findings corroborated those of Lourens *et al.,* (2005), who discovered a significant lower in the body weight of broilers treated either 36.7°C (1 week) or 38.9°C (3 weeks) post-hatch compared to those in the control group. Similarly, El-Shater *et al.,* (2021) reported that Japanese quail eggs subjected to early thermal manipulation had a lower embryo weight compared to control. In contrast, findings were obtained by Al-Rukibat *et al.,* (2017) found that broiler chickens maintained thermally at 38.5 and 40.0°C experienced an increase in body weight on day 42 compared to control. Also, Alkan e*t al.,* (2013) found a significant increase in body weight of quail chicks produced from eggs exposed to 41˚C for 3 hours during the period from 3 days (6-8d) as compared with those of the control group. Similarly, Avşar *et al.,* (2022) showed that an egg temperature of 38.6 °C during the first 6 days of incubation did not affect broiler chick weight.

Table 1. Impact of thermal manipulations on the body weight of quails

Traits	Experimental groups				SEM	P-Value
	1st (Control)	2nd (STM)	3rd (MTM)	4th (LTM)		
BW (1day)	7.60	7.57	7.49	7.3	0.15	0.6159
BW (7day)	25.86	27.22	27.46	27.26	0.88	0.5715
BW (14day)	62.07	62.10	62.14	60.06	1.36	0.6505
BW (21day)	98.67	96.22[a]	97.63	94.29	3.05	0.7643
BW (28day)	126.24	121.11	125.94	118.65	3.79	0.4414
BW (35day)	184.30[a]	171.66[a]	176.53[a]	165.73[b]	5.73	0.0167
BW (42day)	220.96[ab]	222.41[a]	220.61[ab]	205.27[b]	5.07	0. 0162

[A, b] Means of different labels in the same row are statistically different (P≤0.05). STM= Short thermal manipulation, MTM= Middle thermal manipulation, LTM= Long thermal manipulation, BW= Body weight, SEM= Standard error of mean

2. Body weight gain:

Regarding the effect of thermal manipulations on body weight gain, these results showed that the daily and total weight gain during (28–24 d) and (1–42 d) for chicks hatched from manipulated eggs with long thermal manipulation (4th group) was significantly deceased than those in the 1st (control), 2nd (STM), and 3rd (MTM) groups. According to Faria Filho *et al.,* (2007), the reduction in protein digestibility, lipids, and starch as a result of deleterious effect heat stress could be responsible for the decrease in body weight gain of chicks. These findings are in line with those of Jahanian and Rasouli (2015), who found that broilers exposed to heat stress had significantly lower body weight gains than broilers maintained in a thermo-neutral

environment. Similar findings were found by Mehaisen *et al.*, (2017), who noted that the BWG for quail chicks subjected to heat stress was significantly lower compared with those in the control group from 28 to 35 days of age. In line with this trend, Fouad (2023) found that early embryogenesis at high incubation temperatures (40.0°C) led to significantly lower body weight gains for chicks than at normal (37.5 °C), and low (35°C) incubation temperatures.

Table 2. Impact of thermal manipulations on the body weight gain of quails

Traits	Experimental groups				SEM	P-Value
	1st (Control)	2nd (STM)	3rd (MTM)	4th (LTM)		
DWG (0-14d)	3.89	3.89	3.90	3.77	0.09	0.7008
DWG (14-28d)	4.58	4.21	4.56	4.18	0.19	0.3192
DWG (28-42d)	6.77^{ab}	7.23^{a}	6.76^{ab}	6.19^{b}	0.25	0.0507
DWG (1-42d)	5.08^{ab}	5.11^{a}	5.07^{ab}	4.71^{b}	0.12	0.0408
TWG (1-24d)	213.36^{ab}	214.84^{a}	213.12^{ab}	197.94^{b}	5.05	0.0508

A, b Means of different labels in the same row are statistically different (P≤0.05). STM= Short thermal manipulation, MTM= Middle thermal manipulation, LTM= Long thermal manipulation, TWG= Total weight gain, DWG= Daily weight gain, SEM= Standard error of mean

3. Feed intake:

According to Table 3, there was no significant effects in the daily feed intake of quail chicks produced from eggs thermally manipulated with high incubation temperatures (4th group) during the 1–14, 14–28, and 28–42 days of age compared to those in the control, STM, and MTM groups, respectively. The total feed consumption of quail chicks in the fourth group was significantly lower compared to the control, STM, and MTM groups during the period from 1 to 42 days of age. The deleterious effects of heat stress may have contributed to the significant reduction in feed consumption. As a result, this aspect may have contributed to the decreased feed consumption after hatching (Wyatt *et al.*, 1985). These findings corroborated those of Sahin and Kucuk (2003), who reported that quails suffer economic losses due to high ambient temperatures by consuming less feed and using nutrients and feed more inefficiently. Similar findings were also found by Jahanian and Rasouli (2015), who noted that broilers reared in a thermoneutral environment showed significantly higher weight gain as well as feed consumption compared with those in thermal stress condition. These results corroborated those of Afsarian *et al.*, (2017), who found that the old Arian breeder flock was thermally manipulated at 39.5 °C with significantly less feed than those in the control group. In the same manner, Also, Havlicek and slama (2011) found that the Isa Brown laying hens exposed to chronic high temperature (27°C) significantly ($p<0.05$) decreased feed intake during the first seven days of the heat stress by about 18% as compared with that of the control group.

Table 3. Impact of thermal manipulations on the feed intake of quails

Traits	Experimental groups				SEM	P-Value
	1st (Control)	2nd (STM)	3rd (MTM)	4th (LTM)		
DFI (1-14d)	8.74	8.25	8.60	8.30	0.22	0.3733
DFI (14-28d)	17.10	16.30	15.72	15.10	0.62	0.1813
DFI (28-42d)	29.10	29.50	29.20	28.36	0.46	0.3887
TFI (0-42d)	769.16[a]	756.73[ab]	749.28[ab]	724.64[b]	12.2	0.0222

[A, b] Means of different labels in the same row are statistically different (P≤0.05). STM= Short thermal manipulation, MTM= Middle thermal manipulation, LTM= Long thermal manipulation, TFI= Total feed intake, DFI= Daily feed intake, SEM= Standard error of mean.

4. Feed conversion ratio:

The data obtained and presented in Table 4 regarding the impact of thermal manipulation on feed conversion ratio revealed that daily and total feed conversion ratios in different groups were not significantly affected. These results agreed with those of Joseph *et al.*, (2006), who reported that broiler chicks thermally exposed to 39.4°C during early (0-10 d) embryogenesis compared to controls did not significantly differ in feed conversion ratio. Additionally, Collin *et al.*, (2007) showed no difference in the feed conversion ratio between the control and chicks thermally treated with 41°C at 28 or 42 days. The feed conversion ratio for chicks thermally treated with 39.5°C (2 h daily) during the incubation phase and the control group did not differ significantly (Halle and Tzschentke (2011). Also, Sardary *et al.*, (2015) found no significant differences in feed consumption and feed conversion ratio for Ross 308 chicks subjected to thermal manipulations at (38.4°C) for 6 hours daily at 19 and through 3hours at day 19 and 20 of incubation as compared with those of the control group.

Table 4. Impact of thermal manipulations on the feed conversion ratio of quails

Traits	Experimental groups				SEM	P-Value
	1st (Control)	2nd (STM)	3rd (MTM)	4th (LTM)		
DFC (1-14d)	2.25	2.12	2.21	2.21	0.06	0.5068
DFC (14-28d)	3.77	3.87	3.49	3.63	0.21	0.6096
DFC (28-42d)	4.31	4.10	4.35	4.62	0.22	0.4346
TFC (1-42d)	3.61	3.53	3.52	3.68	0.11	0.6960

[A, b] Means of different labels in the same row are statistically different (P≤0.05). STM= Short thermal manipulation, MTM= Middle thermal manipulation, LTM= Long thermal manipulation, TFC= Total feed conversion, DFC= Daily feed conversion, SEM= Standard error of mean.

REFERENCES

Abuoghaba, A. A., Abdelfattah, M. G., Ali, Fatma., and Abdelwahab, Amira A. M. (2023). Impact of spraying eggs with betaine after exposure to short-term thermal stress during early embryogenesis on pre and post-hatch performance of Japanese quail. Journal of thermal biology 111, 103427.

Afsarian, O., Shahir, M. H., Lourens, A., Akhlaghi, A., Lotfolahian H., Hoseini, A. and Mousavi, N. (2017). Eggshell temperature manipulations during incubation and in ovo injection of thyroxine are associated with a decreased incidence of cold-induced ascites in broiler chickens. Poultry Science 0:1-9.

Alkan, S., Karsli. T., Karabag, K., Gali, A. and Murat, S. B. (2013). The effects of thermal manipulation during early and late embryogenesis on hatchability, hatching weight and body weight in Japanese quails (Coturnix coturnix japonica). Archiv Tierzucht, 78, 789-796.

Al-Rukibat, R. K., Al-Zghoul, M. B., Hananeh, W.M., Al-Natour, M.Q., and Abu-Basha, E. A. (2017). Thermal manipulation during late embryogenesis: Effect on body weight and temperature, thyroid hormones, and differential white blood cell counts in broiler chickens. Poultry Science., 96, 234-240.

Avşar, K. O., Uçar, A., Özlü, S., and Elibol, O. (2022). Effect of high eggshell temperature during the early period of incubation on hatchability, hatch time, residual yolk, and first-week broiler performance1. J. Appl. Poult. Res., 31, 100197.

Christensen, V.L., Grimes, J.L., Wineland, M.J., Davis, G.S. (2003). Accelerating embryonic growth during incubation following prolonged egg storage. 2. Embryonic growth and metabolism. Poult. Sci., 82,1869-1878

Collin, A., Berri, C., Tesseraud, S., Rodon, F. R., Skiba-Cassy, S., Crochet, S., Duclos, M. J., Rideau, N., Tona, K. and Buyse, J., (2007). Effects of thermal manipulation during early and late embryogenesis on thermotolerance and breast muscle characteristics in broiler chickens. Poultry Science 86 (5), 795-800.

Duncan, D. B. (1955). Multiple range and multiple F tests. Biometrics 11:1-42.

Faria Filho D.E., Campos, D.M.B., Alfonso-Torres, K.A., Vieira, B.S., Rosa, P.S., Vaz, A.M., Macar, M., and Furlan, R.L. (2007). Protein levels for heat-exposed broilers: performance, nutrients digestibility and energy and protein metabolism. International Journal Poultry Science, 6:187-194.

El-Shater, Saad N., H. Rizk, Hisham, Abdelrahman, A., Awad, M.A., Khalifa, E. F. and Khalil, K.M. (2021). Embryonic thermal manipulation of Japanese quail: effects on embryonic development, hatchability, and post-hatch performance. Trop Anim Health Prod., 253-263.

Fouad, M.A. (2023). Impact of thermal stress and some manipulations on embryonic development and physiological responses of chickens. Ph.D. Thesis. Poultry Production Department, Faculty of Agriculture, Sohag University, Sohag, Egypt.

Halle, I. and Tzschentke, B. (2011). Influence of temperature manipulation during the last 4 days of incubation on hatching results, post-hatching performance and adaptability to warm growing conditions in broiler chickens. 48:97- 105.

Havlicek, Z. and Slama, P. (2011). Effect of heat stress on biochemical parameters of hens. J Proceedings of ECO pole.1:58-60.

Holland S., Nichelmann M. and Höchel J. (1997). Development in heat loss mechanisms in avian embryos, Verh. Dtsch. Zool. Ges. 90 105.

Jahanian, R., and Rasouli, E. (2015). Dietary chromium methionine supplementation could alleviate immunosuppressive effects of heat stress in broiler chicks. J Anim Sci., 93, 3355-3363.

Janke, O., Tzschentke, B., Ho ¨chel, J., and Nichelmann, M. (2002). Metabolic responses of chicken and Muscovy duck embryos to incubation temperatures. Comp. Biochem. Physiol. A131:741-750.

Joseph, N. S., Lourens, A. and Moran, E. T. Jr. (2006). The effects of suboptimal eggshell temperature during incubation on broiler chick quality, live performance, and further processing yield. Poult. Sci. 85:932–938.

Leksrisompong, N.; Romero-Sanchez, H.; Plumstead, P. W.; Brannan, K. E. and Brake, J. (2007). Broiler incubation. 1. Effect of elevated temperature during late incubation on body weight and organs of chicks. Poult. Sci. 86: 2685–2691.

Lourens, A., Van den Brand, H., Meijerhof, R., and Kemp, B. (2005). Effect of eggshell temperature during incubation on embryo development, hatchability, and posthatch development. Poult Sci., 84, 914-920

Mehaisen, G.M.K., Ibrahim, R.M., Desoky, A.A., Safaa, H.M., El-Sayed, O.A., and Abass, A.O. (2017). The importance of propolis in alleviating the negative physiological effects of heat stress in quail chicks. PLoS ONE 12(10): e0186907

Molenaar, R.; Reijrink, I. A. M.; Meijerhof, R. and Van Den Brand, H. (2008). Relationship between hatchling length and weight on later

productive performance in broilers. Worlds Poult. Sci. J. 64:599–604.
Nowaczewski, S., Witkiewicz K., Kontecka H., Krystianiak S. and Rosiński A. (2010). Eggs weight of Japanese quail vs. eggs quality after storage time and hatchability results. Archiv Tierzucht, 6, 720-730, ISSN 0003-9438
Peebles, E.D.; Zhai, W. and Gerard P.D. (2012). Comparative evaluation of air cell and eggshell temperature measurement methodologies used in broiler hatching eggs during late incubation. Poult. Sci. 91:1536-1541.
Piestun, Y., Shinder, D., Ruzal, M., Halevy, O., Brake, J., and Yahav, S. (2008). Thermal manipulations in late-term chick embryos have immediate and longer-term effects on myoblast proliferation and skeletal muscle hypertrophy. Poultry Science 87, 1516–1525.
Romao, J.M., Moraes, T.G.V., Teixeira, R.S.C., Buxade, C.C., and Cardoso, W.M. (2009). Incubation of Japanese quail eggs at different temperatures: hatchability, hatch weight, hatch time and embryonic mortality. Arch. Vet. Sci. 14:155–162.
Runjai´c-Anti´c, D., Pavkov, S., and Levi´c, J., (2010). Herbs in a sustainable animal nutrition. Biotechnol. Anim. Husb. 26, 203-214.
Sahin, K. and Kucuk, O. (2003). Heat stress and dietary vitamin supplementation of poultry diets. Nutr. Abs. and Rev. Series B Livestock Feeds and Feeding 73:41–50.
Sardary, S.Y., Husain, T.S., Mustafa, H., and Abas, K.A. (2015). Effects of temperature manipulation during late embryogenesis on broiler performance. Zanco J. Pure Appl. Sci. 27 :29–34.
SAS. (2004). Statistical Analysis Systems Institute. 2004. SAS/STAT User's Guide: Release 6.03. SAS institute Inc., Cary, NC.
Wyatt, C.L.; Weaver, W.D. Jr. and Beane, W.L. (1985). Influence of egg size, eggshell quality and post hatch holding time on broiler performance. Poultry Science, 64: 2049–2055.

تأثير المعالجة الحرارية قصيرة وطويلة المدى خلال مرحلة التطور الجنيني المبكر على الأداء الإنتاجي في السمان

أحمد عبدالكريم ابوغابة[1]، زينهم شيخون حسن إسماعيل[1]، حماده عبدالحميد مهني علوان[2] ، هبه جمال[1]
[1] قسم انتاج الدواجن- كلية الزراعة- جامعة سوهاج
[2] قسم الإنتاج الحيواني- كلية الزراعة- جامعة المنيا

الملخص العربي

أجريت هذه الدراسة بمزرعة الدواجن البحثية، قسم إنتاج الدواجن، كلية الزراعة، جامعة سوهاج، سوهاج، مصر. وهدفت إلى تقييم تأثير المعالجة الحرارية قصيرة وطويلة المدى اثناء مرحلة التطور الجنيني المبكر (اليوم الرابع – اليوم السادس) على الأداء الإنتاجي في السمان. اشتملت هذه الدراسة على 600 بيضة سمان قسمت بالتساوي لأربع مجموعات (4 مجموعات × 5 مكررات × 30 بيضة). في المجموعة الأولى (الكنترول)، تم تحضين البيض عند درجة حرارة 37.5 درجة مئوية ورطوبة نسبية 55-60% من اليوم الأول حتى اليوم الرابع عشر من التفريخ. تم تعريض بيض المجموعة الثانية (المعالجة الحرارية القصيرة)، الثالثة (المعالجة الحرارية المتوسطة) والرابعة (المعالجة الحرارية الطويلة) يوميا إلى 39.0 درجة مئوية و55-60٪ من اليوم الرابع الى اليوم السادس خلال مرحلة التطور الجنيني المبكر لمدة 3، 6 و12 ساعة على التوالي.

ولخصت نتائج الدراسة الى ما يلي:

- أظهرت النتائج انخفاض معنوي بوزن الجسم عند عمر 35 و42 يوماً للكتاكيت بمجموعة المعالجة الحرارية طويلة المدى (المجموعة الرابعة) مقارنة بكتاكيت مجموعة الكنترول (الأولى) وكتاكيت مجموعتي المعالجة الحرارية قصيرة المدى (الثانية)، ومتوسطة المدى (الثالثة).
- اوضحت النتائج وجود انخفاض معنوي بمعدل الزيادة الوزنية اليومية والكلية خلال (14-28يوم) و(1-42يوم) بكتاكيت المجموعة الرابعة مقارنة بمثيلاتها بمجموعة الكنترول (الأولى)، ومجموعتي المعالجة الحرارية قصيرة المدى (الثانية)، ومتوسطة المدى (الثالثة).
- انخفض استهلاك العلف اليومي معنويا بكتاكيت المجموعة الرابعة خلال الأعمار 1-14، 14-28، 28-42 يوماً، مقارنة بمجموعة الكنترول ومجموعتي المعالجة الحرارية القصيرة (الثانية)، والمتوسطة (الثالثة).
- انخفض استهلاك العلف الكلى معنويا بكتاكيت السمان بالمجموعة الرابعة خلال عمر 1-42 يوم مقارنة بمجموعة الكنترول ومجموعتي المعالجة الحرارية قصيرة المدى (الثانية)، ومتوسطة المدى (الثالثة).
- لم يكن للمعالجة الحرارية تأثير معنوي على معدل التحويل الغذائي اليومي والكلي طوال فترة التجربة.

واوصت الدراسة باستخدام المعالجة الحرارية قصيرة (3 ساعات/يوم) ومتوسطة المدي (6 ساعات) خلال فترة التفريخ لما لها من تأثير مفيد على نمو طيور السمان خلال فترة النمو وذلك بالمقارنة بالمعالجة الحرارية طويلة المدى (12 ساعة).

الكلمات المفتاحية: المعالجة الحرارية القصيرة والطويلة، الأداء الإنتاجي، طائر السمان.