PERFORMANCE EVALUATION FOR LOCAL MANUFACTURED HEATING SYSTEM FOR HEATING BROILER HOUSE

Ghoname, M. S[*] ; A.M, EL -Metwally[**] and T.Z. Fouda[***]

ABSTRACT

The experimental work was held in commercial broiler house at Babil village, Menofia Governorate, latitude and longitude angles are 30.67°N and 30.98°E, respectively) during winter season of 2015 in order to evaluate the performance of manufactured heating system and its effect on indoor air temperature and energy requirements.

The indoor air temperature above the floor surface, indoor air relative humidity, fuel consumption, heat energy addition and specific heating power for every cubic meter of house volume were measured and specific fuel consumption also. Broilers performance evaluation was also determined in terms of live body mass. The obtained results showed that using manufactured heater in heating broiler house the weekly average indoor air temperature ranged between 31.61 to 23.26 ºC at first and fifth week respectively. Whereas, the indoor relative humidity ranged between 26.15 to 52.48% at the same ages. The average heat energy addition to the house was 63.28 kW throughout the bird's life and specific heating power was 148.4 W/m ^{3} at the first week and reduced to be 37.07 W/m ^{3} at fifth week. Heating energy requirements decreased from 422.59 kJ/h.kg at the first week of age until reached to 19.45 kJ/h.kg at fifth week of age where the average broilers body mass was 2.2 kg.

INTRODUCUTION

Heating broiler houses for provide a better thermal environment is important in broiler houses for maximizing broilers meat production especially during the first seven to ten days of the chick's life. Because, in the first week their body temperature, metabolic rate, body mass to surface area ratio, insulation from feathering and thermoregulatory ability are all relativity low .

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If birds are kept at a temperature that is lower than the target optimum temperature, the birds increase their feed intake and use more of the feed energy to keep their body's warm, which increases the production cost and decreases the meat yield. In 2013, Egyptian production of poultry meat reached 945775 tones and the total national production of chicken's meat was 834000 tones **(FAO, 2015).** Heating broilers houses using hot air generator have a problems such as it have high fuel consumption in their operating , increasing their prices and lowest heat energy added to the house which influence the indoor air temperature to be lower than the recommended level. Thus, adversely effect on broiler health, increasing mortality, and decreasing feed conversion efficiency for this reasons.

Fairchild and Czarick (2005) reported that, reducing furnace/brooder temperature settings can reduce heating costs, and it can have a significant effect on chick performance. Brooding at 29.4°C vs 32.2°C the first week can result in feed conversion differences of two points or more and lower body weights. This can be demonstrated by the differences of up to 4 % in seven day mortality. **Ghoname et al., (2012)** conduct a trial using forced air heating system with and without perforated poly ethylene tube and they found that, at first week of age average house temperature was 29.7 °C and reduced to be 21.3°C at five weeks of age when heating broiler house without using duct. But when using perforated duct for heat distribution the average house temperature was 31.2 °C at the first week and reduced to be 23 °C at five weeks of age in addition , using forced air heating system save gas consumption by 32.6%, reduce litter moisture content from 41.5 to 32.8 %, reduce supplementary heat from 45.72 to 32.4 kW and

Fouda et al. (2013) study the effect of using forced air heating system on broiler house environment and they found , the average floor house temperature was lower the recommended by 11.8 % through the life cycle, the indoor relative humidity was increased from 43.7 % in the first week of age until reached to 71.3% at fifth week of age., heating energy requirements reduced gradually with increasing birds in age from 308.9 kJ/h.kg at the first week of age until reached to 19.2 kJ/h.kg at fifth week of age whereas, the broilers body mass was increased from 0.13 kg at the first week of age until reached to 1.9 kg at fifth week of age . **Arbor**

Acers Management Guide (2014) mentioned that Chicks cannot regulate their own body temperature until they are around 12-14 days of age. Optimal body temperature must be attained through provision of optimal environmental temperature. Floor temperature at chick placement is as important as air temperature, so preheating the house is essential. Houses should be preheated for a minimum of 24 hours prior to chick arrival. Temperature and relative humidity (RH) should be stabilized at recommended values to ensure a comfortable environment for the chicks upon their arrival. It may be necessary to preheat houses for longer than 24 hours prior to chick arrival to allow the internal structure of the house to be warmed effectively. The period required for preheating will be dictated by length of time between crop cycle placements and geographical region (those with sub-zero winter months may require a longer period of preheating).

The main objectives of theses study are to:

Evaluate a local manufacture heating system, provide a better thermal environment and increase meat production.

MATERIALS AND METHODS

The experimental work was carried out commercial broiler house at Babil, Menofia Governorate, which located at latitude and longitude angle of 30.67°N and 30.99°E, respectively, during winter season of 2015. The floor surface area of broiler house which was functioned during the experimental work was 502 m^2, and house volume, 1557.75 m^3. It is orientated with East-West direction.

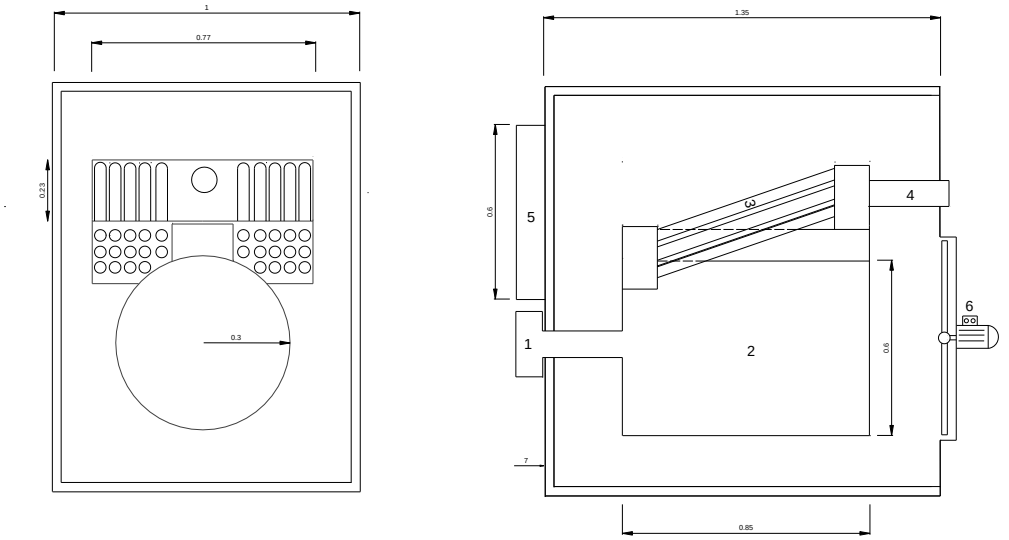
Manufactured heater

The manufactured heater was functioned during the heating period of experimental work (winter season of 2015). The hot air heating system consists of (furnace, counter flow heat exchanger made of steel A161 (carbon molybdenum steel) , axial fan 63 cm taken its motion directly from electric motor three phase with 1.5 kWh in power). The air fan capacity is 10,000 m^3/h as shown in fig (1)

Oil burner: the oil burner (model Riello Guilliver , ITALY,393 T1, Gas oil) was used during the experimental work. The output and thermal power was between 7-15kg/h and 83-178kW respectively. The calorific value of oil gas is 41.8 MJ/kg and its density is 0.8 gm/cm^3

Chicks

Hybrid Arbor Acers chicks one day age with average mass of 40g reared in the experiments



All dim. in m

Parts	burner	Furnace	Heat exchanger tube	Chimney	Air out let	Axial fan	Heater body
No	1	2	3	4	5	6	7

Fig (1) Schematic diagram illustrated cross section in manufactured heating system

Instrumentations

a-Data logger

One data-logger device (16 channels) was used for collecting and recording reading from the different sensors (Thermstors) located at different positions inside the broiler house. Data-logger has key-board and monitor. Computer program (Lap Jack and Profilap) were employed .The Lap Jack program was used to run the data-logger on the computer and a Profilap was functioned to convert the reading from analog to digital. The time interval for data recording was 5 minutes with data acquisition every one minute for integrated measurements. The calibration of all sensors and the data logger were completed successfully at the beginning of the experimental work.

b- Hygrometer

Thermo- Hygrometer (model TFA) with range of 10-99 % was used to measure relative humidity inside and outside the house with ± 5% accuracy .

Measurements

Temperature measurements

Sensors were used to measure the air temperatures inside and outside the broiler house. Inside the broiler house, air temperatures were measured at twelve different locations along-side of broiler house on 25 cm above the floor surface then the temperature averages was taken in calculation., Sensors were used to measure the out blown air temperatures from the heater, the air temperature behind the blower .

Relative humidity measurements

Indoor relative humidity and out door relative humidity was also measured using digital hygrometer.

Methods:

The experiment was conducted at broiler house in one living cycle, with total complement of 5000 birds one day age (Arbor Acers hybrid). The living cycle was started on 10/2/2015. This living cycle was taken five weeks (35 days) until 16/3/2015.

The heating system was adjusted to provide a 34ºC in at the first day of chicks live and was reduced gradually 3ºC every week until reached 24 ºC at age of five weeks. Heating system sensor was at height of 25 cm of floor surface and was in the middle of brooding area and far 2.5 m near the house south wall.

During living cycle, the chicks were brooded in two successive stages. In the first chicks brooding, all birds were brooded on small floor surface area (180. m^2) for seven days of the chick's life to regulate their metabolic processes to adequately control their body temperatures. The small floor surface area of brooding operation during the second stage was increased to 330 m^2 . After 18 days the curtain was removed and the chick spread on all the floor surface area of the boiler house until the end of living cycle.

Calculation

Heating Energy addition

The forced air heating system supplies heat energy inside the broiler housing. This heat energy supply can be calculated in terms of the mass

flow rate of air (m) in kg/s, specific heat of inlet air (C_p) in J/kg °C, and the temperature difference between hot air (T_o) and cold air (T_i) in °C, as follows:

$$Q_{add} = m\ C_p\ (T_o - T_i)/1000 \quad kW \qquad (1)$$

Specific heating power for every m^3 of the house volume

The specific heating power required to heat 1 m^3 of broiler house volume was calculated according to the heat energy supply (Q_{supply}) in kW and the volume of house (V_h) in m^3, using the following equation:

$$Sp = Q_{add}/V_h \quad , \quad W/m^3 \qquad (2)$$

Specific fuel consumption

Fuel consumption really which was used for rise the temperature in the house ambient 1 ºc.

$$S.f.c = \frac{n.f.c}{TR} \qquad (3)$$

Where:

S.f.c= Specific fuel consumption, kg/h.ºC.

n.f.c = fuel consumption in the operating time, kg/h.

Energy requirements for kg of broiler body mass

$$Energy\ \text{requierments} = \frac{Q_{add}}{Total\ \text{body mass}} \qquad (4)$$

Where :

Energy requirements = kJ/hr.kg

Q_{add} = Heat energy addition, kJ/hr.

RESULTS AND DISCUSSION

Effect of heating systems on indoor air temperature

The relationship between indoor air temperature and broiler age when using manufactured heating system inside broiler housing through out living cycle was revealed in fig (1) with increasing broilers in age the indoor air temperature is decreased that's as result of increasing chicks in body weight which mean more heat production is released, increasing metabolic rate, body mass to surface area ratio, insulation from feathering and thermoregulatory ability. Fig (1) showed that, the average indoor setting temperature was ranged between 32.7°C at the first week of clicks'

age and reduced to be 24.28°C at the fifth week of age. Data showed that, indoor air temperature was close to the setting temperature through living cycle and put the birds in comfort zone and enhanced feed conversation efficiency.

Indoor air temperature at age five days of brooding (first brooding stage) inside the broiler house when using manufactured heating system is shown in figure. (2). in this period of life the recommended brooding temperature set is 32ºC. The data also showed that using manufactured heating system the average indoor air temperatures were ranged between 30.92ºC to 32.7 ºC at 04:00 and 20:00, respectively. In this case, the lowest difference between setting and indoor air temperature was 1.1 ºC at 04:00.While during age of 14 days of brooding (second brooding stage) the recommended brooding temperature set is 29ºC. The data also showed that using manufactured heating system the average indoor air temperatures were ranged between 28.9 ºC to 32.2 ºC at 21:00 and 09:00, respectively. In this case, the lowest difference between setting and indoor air temperature was 0.1 ºC at 21:00.

Finally during age of 22 days of brooding (third brooding stage) the recommended brooding temperature set is 26.5 ºC. The data also showed that when using manufactured heating system the average indoor air temperatures were ranged between 23.8 ºC to 27.2 ºC at 15:00 and 09:00, respectively. In this case, the lowest difference between setting and indoor air temperature was 2.7 ºC at 15:00.

Effect of heating systems on indoor air relative humidity

Indoor air relative humidity level is on of the most important air quality variables. Indoor air relative humidity in poultry houses should be 50-70% . Fig (2) illustrated the relation between weekly average indoor air relative humidity when using manufactured heating systems for heating broiler house. The relation between broiler's age and indoor air relative humidity is directly proportional. With increasing broilers in age the indoor air relative humidity is increased. Fig (3) showed that, the average indoor air relative humidity was 26.14 % at first week and increased to be 51.75 % of experiment when using the manufactured heater in heating broiler house. Data showed that, using manufactured heater maintain

indoor air relative humidity to be in the recommended level through birds live periods.

Indoor air relative humidity at five days of age (first brooding stage) inside the broiler house when using manufactured heating system is shown in figure (4). Data showed that using manufactured heating system the lowest value of indoor air relative humidity was 24.5 % at 12:00 with out door relative humidity 42% and the highest value was 32.5% at 18:00 with out door relative humidity 45%. While during 14 days of age (second brooding stage) .Data showed that using manufactured heating system the lowest value of indoor air relative humidity was 33.3 % at12:00 with out door relative humidity 72% and the highest value was 48.3 % at 06:00 with out door relative humidity 88%. Finally during age of 22 (third brooding stage) .Data showed that using manufactured heating system the lowest value of indoor air relative humidity was 38.4 % at12:00 with out door relative humidity 45% and the highest value was 55.2 % at 18:00 with out door relative humidity 90%

Effect of heating systems on heat energy addition and specific heating power (Sp)

At first of chick's life the require temperature inside the house is relative high at contrast, sensible heat from birds in this period is low because, birds body mass is low. So, Supplementary heat add to the house is too high. The relation between broiler's age and heat supplementary add is adversely proportional. Because, increasing birds in age, the indoor temperature decreases. In other hand sensible heat from birds increase. The previous relation depends on outside air temperature, building materials, building volume and bird's kind. Fig (5) revealed the relation between heat energy addition and specific heating power W/ m^3 of house volume during bird's age. It evidently revealed that, during the live cycle when employed the manufactured heater for heating, the heat energy addition to the house was 82.80 kW at the first week and decreased gradually until reached to 47.97kW at the fourth week.

Specific heating power depends mainly upon the heat energy addition to the broiler house during heating operation and the volume of that house. As, the bird's age increased, the specific heating power was decreased. Specific heating power during living cycle when the manufactured

heating system was used was 148.4 W/m^3 at the first week of age and reduced gradually till reached 31.24 W/m^3 at the fourth week of age, after that, it increased again until reached 37.07 W/m^3 at the fifth week of age. This resulted help in rise the house floor surface temperature to be close to the recommended level and put the birds into thermal comfortable zone. Thus, birds were more comfortable which enhanced and increased the feed conversion efficiency.

Effect of heating systems on fuel consumption and specific fuel consumption (S.F.C))

The relation between fuel consumption and bird's age depends on the amount of heat energy added to maintain the house temperature in the recommended range and put the birds in thermal comfort zone to increase meat production. Fig (6) revealed the relation between fuel consumption, and specific fuel consumption during bird's age. It evidently revealed that, during the live cycle when employed the manufactured heater for heating , the house fuel consumption was 4.07 L/h at the first week and decreased gradually until reached to 2.19 L/h at the fourth week .It was increased after that to be 3.25L/h at the end of broiler life . Specific fuel consumption depends on heater fuel consumption and temperature rise. As, bird's age increase, specific fuel consumption decreased. It evidently revealed that, during living cycle when employed the manufactured heater for heating, the specific fuel consumption was 0.2304 kg/h.°C at the first week and decreased gradually until reached to 0.865 kg/h.°C at the third week .After that specific fuel consumption increased again till it reached 0.2309 kg/h.°C at the fourth week of broiler life and reduced to be 0.1459 kg/h.°C at the fifth week.

Effect of heating systems on broiler body mass and heating energy requirements

The heating energy requirement is dependent up only in broiler age and mass. As birds increased in age, the body mass increased and sensible heat from birds increased also. As a result, the heating energy requirements reduced. Figure(7) showed the relation between heating energy requirements and body mass during birds age .The broilers body mass was increased from 0.142 kg at the first week of age until reached to 2.2 kg at fifth week of age. So, the heating energy requirements decreased

gradually from 422.59 kJ/h.kg at the first week of age until reached to 19.45 kJ/h.kg at fifth week of age.

CONCLUSION

The main results of the present research can be summarized as follows:-

-The manufactured heater increased average floor air temperature through the birds' life by 3.04% comparing with the imported heater resulting in distributing the birds throughout the broiler house and not huddling together or sitting in the feed pans.

-Heating broilers house using manufactured heater the indoor relative humidity ranged between 26.15 to 52.48 % at first and fifth week respectively.

- Using manufactured heater in heating broiler house the average fuel consumption was 2.92 L/h through the birds live.

- The average specific fuel consumption was 0.2218 kg/h. °C through the birds' life.

- The average specific heating power for every m^3 of the house volume was 66.64 W/m^3

-Heating broilers house using manufactured heater the heating energy requirements ranged between 422.6 to 19.45 kJ/kg.hr at first and fifth week respectively.

- Manufactured heating system help in average live body mass to be 2.2 kg at age of fife weeks

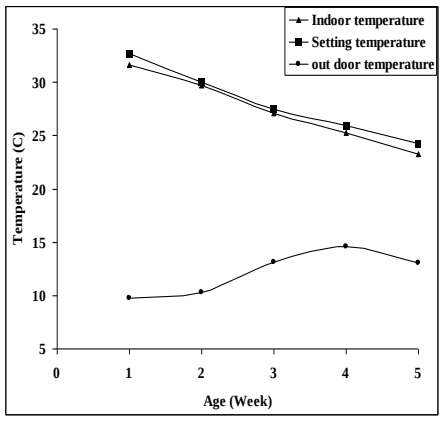


Fig (1) Weekly average indoor air temperature

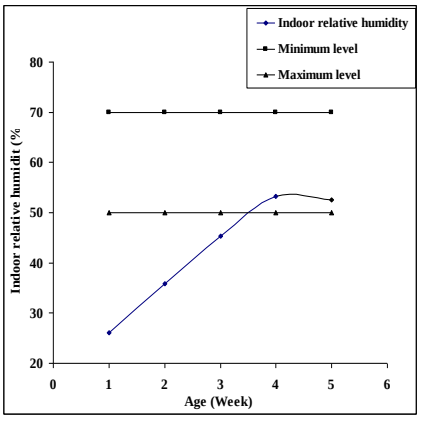
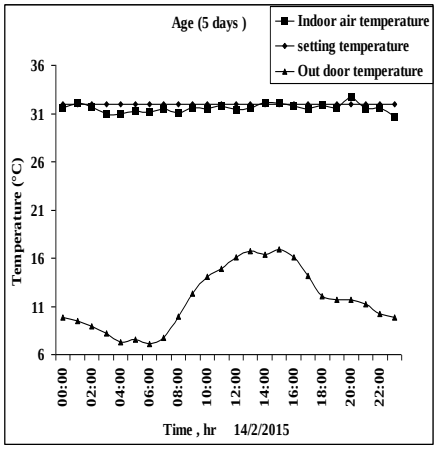
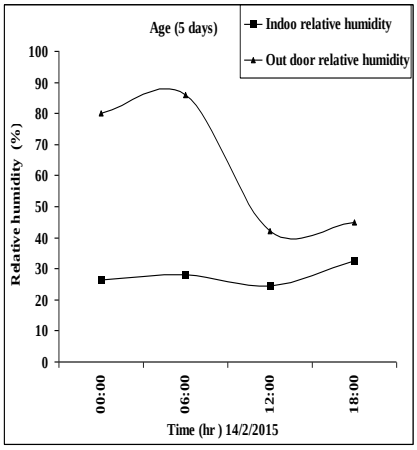
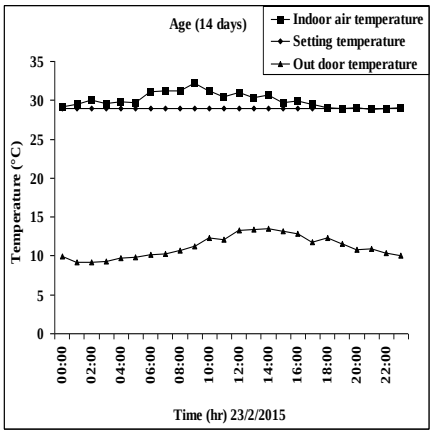
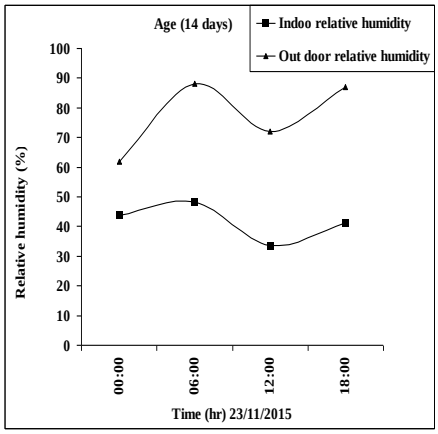


Fig (3) Weekly indoor air relative humidity









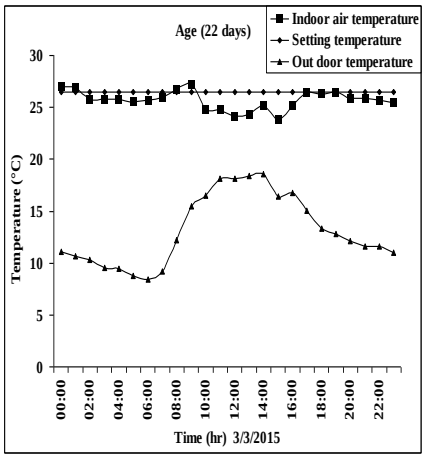


Fig (2) Daily average indoor air temperature

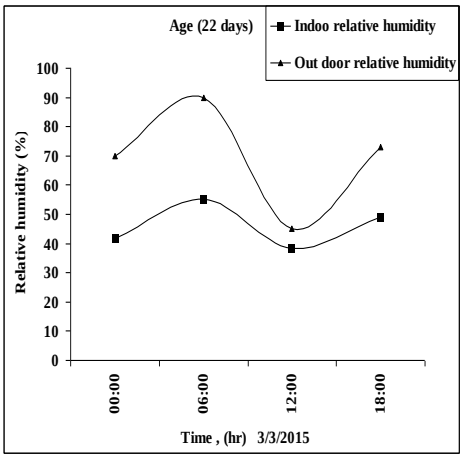


Fig (4) Daily indoor air relative humidity

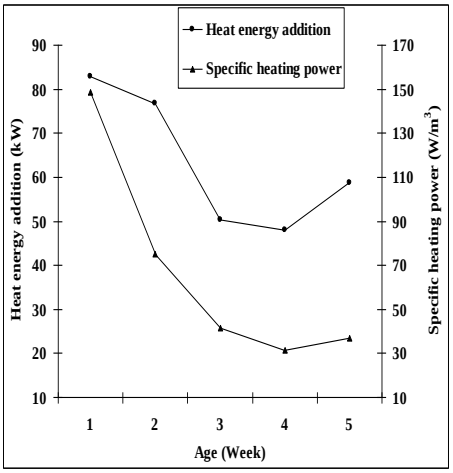


Fig (5) relation between heat energy addition and specific heating power during birds age

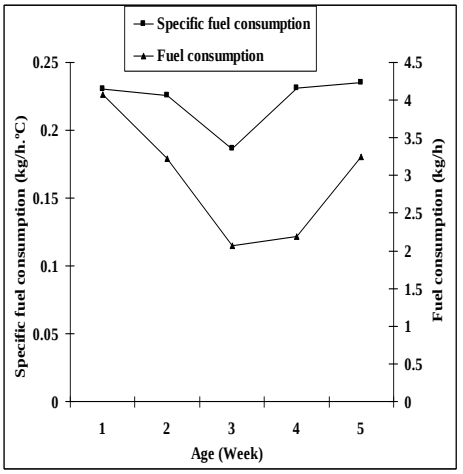


Fig (6) relation between specific fuel consumption and fuel consumption during birds age

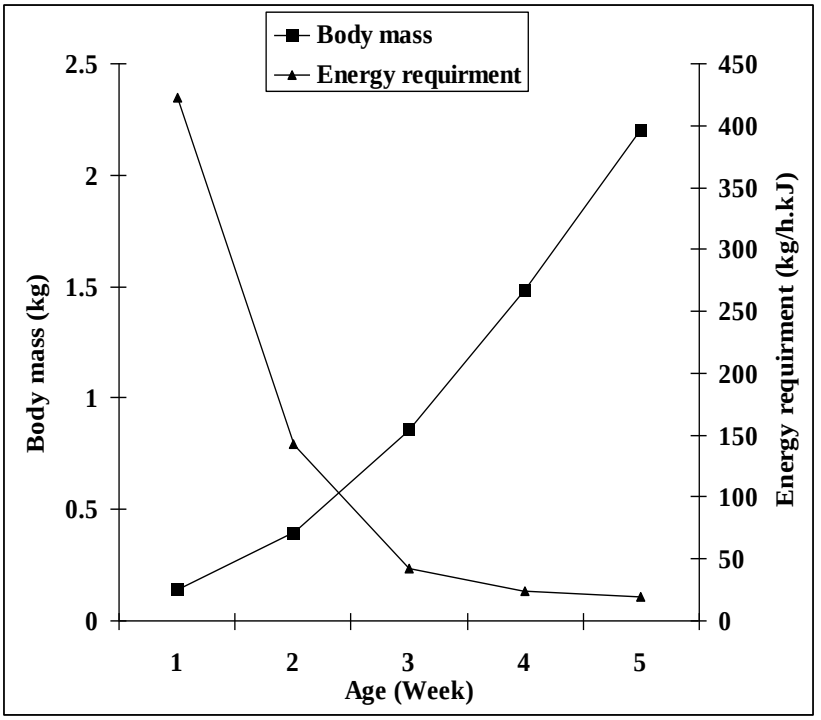


Fig (7) relation between heating energy requirements and body mass during birds age

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الملخص العربى

تقييم أداء نظام تدفئة محلى الصنع لتدفئة مسكن لدجاج التسمين

م.محمد سعيد غنيم* د/.عادل محمد هلال أ.د/ طارق زكى فودة*****

أجريت هذه الدراسة فى شتاء ٢٠١٥ بقرية بابل مركز تلا بمحافظة المنوفية واحداثيات الموقع هى (٣٠,٦٧° شمالا و ٣٠,٩٨°) فى مسكن لانتاج دجاج التسمين والمساحه السطحية لأرض المسكن ٥٠٢م^{2} و توجيه المسكن شرق – غرب . بغرض تقييم نظام تدفئة محلى الصنع لتدفئة مسسكن دجاج التسمين ، توفير بيئة حرارية مناسبة لنموالطيور و زيادة انتاج اللحم و تم قياس درجة الحرارة الجافة فى ١٢ نقطة فى المسكن.

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*****أستاذ الهندسة الزراعية- قسم الهندسة الزراعية ـ كلية الزراعة ـ جامعة طنطا**

وأيضا تم قياس درجة الحرارة الجافة خارج المسكن كذلك تم قياس كمية الحرارة الازمة للتدفئة الطيور ، الرطوبة النسبية للهواء ، الطاقة النوعية لكل متر مكعب من حجم المسكن ، معدل استهلاك الوقود ، الاستهلاك النوعى للوقود ومتوسط وزن الطيور وكانت النتائج التحصل عليها هى كتالى : عند استخدام نظام التدفئة المصنع محليا تراوحت قيم درجات الحرارة بين٣١,٦الى ٢٣,٢٦م° فى الاسبوع الاول والخامس على الترتيب عندما كانت قيم الرطوبة النسبية بين ٢٦,١٥ الى ٥٢,٤٨ % عند نفس الفترة، الطاقة النوعية لكل متر مكعب من حجم المسكن تراوحت بين١٤٧,٤ الى ٣٧,٠١ وات/م^{٣} عند الاسبوع الاول والخامس على الترتيب ، معدل استهلاك الوقود النوعى تراوحت بين ٠,٢٣٠٤الى٠,٢٣٥١ كجم /ساعة. م° عندما كان معدل استهلاك الوقود ٤,٠٧ الى ٣,٢٥ كجم/ساعة وكان متوسط وزن الطيور عند نهاية العمر ٢.٢كجم.