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The Manufacture and Evaluation of a Local Incubator Performance for Hatching Poultry Eggs

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ABSTRACT

The experimental work was carried out to manufacture and evaluate the performance of a local incubator for hatching poultry eggs to attain great production efficiency in a sustained manner, increasing the quality and quantity of production. The manufacture incubator consists of the humidification and turning units, the control panel and the hatchery box. The performance of the fabricated incubator was studied according to the following parameters: Three different levels of temperature (37, 37.5, and 38°C); two different levels of humidity (50 and 55%); and two different levels of egg turning (12 and 24 times per day). The performance of the fabricated incubator was evaluated taking into account the following indicators: incubator efficiency, incubator productivity, and operational cost. Experimental results showed that the suitable operating parameters for hatching poultry eggs using the manufactured incubator were: temperature of 37.5°C, humidity of 55%, and turning of 24 times per day, which recorded the highest incubator efficiency (hatching ratio) and incubator productivity; minimum energy required; and operational costs of 98.44%, 12 chick/day, 14.58 W.day/chick and 1.24 L.E./chick, respectively, also gave the highest quality of the produced chicks.

***Key* words:** Manufacture, incubator, hatching ratio, poultry, eggs, duct system, temperature, humidity, turning, cost.

1. INTRODUCTION

Poultry meat is a major source of high-quality protein and nutrients. In particular, the popularity of poultry meat is increasing in developing countries because of its role in meeting the individual's need for protein nutrition. Egyptian poultry production is one of the most important branches of the animal production sector, which in turn represents the main second sector. Globally, Egypt ranked 71st among exporters of poultry meat while ranking 66th among importers in the world in 2021. Locally, the produce of poultry reached 2245 Gg in 2021 **(Ahmed, 2023)**. The incubation process is one of the most crucial aspects of the poultry industry. Undoubtedly, the growing demand for poultry products is the prime mover in the mechanical and technological development of the poultry industry. As **Kommey *et al.* (2022)** pointed out that technologies, which help to maximize the yield are necessary because it is inefficient to rely solely on natural methods of egg hatching to boost chicken output, and the artificial incubation technologies must come into force due to the rising demand. The artificial incubators are considered the best solution to manual incubators that are negatively affected by a labor shortage since the factors are provided and checked by workers, who frequently cannot identify any variation from the required standards. Two basic parameters that need to be regulated are temperature and humidity. Overly high or low temperatures or improper humidity management during incubation can lead to a number of problems **(Dutta and Anjum, 2021)**. Although the types of modern incubators vary according to size, light source, and ventilation system inside them, they originally use precision-measured devices for accurate reading and adjusting transaction standards, in addition to simplicity of construction, ease of control and management, and raising production efficiency. **Hassan *et al.* (2021)** evaluated and used two types of poultry egg incubators. The first one was the traditional poultry incubator (electric incubator), which was 57×66×59 cm in dimensions with a capacity of 125 hen eggs. The second one was the thermochemical poultry egg incubator, which was designed 56x39x28.5 cm in dimensions with a capacity of 25 eggs. Both contained sensors to control and measure the temperature of 37.5 °C and humidity of 65% inside. They found that the percentage of hatchability for traditional and prototype incubators was 80.9% and 71.4%, respectively. **El-Sebaee (2019)** designed a new solar home incubator system, which was formed from a motor to rotate the egg automatically every four hours and heating resources, work by solar cell and a programmable integrated circuit to control the incubator factors. The average temperature was kept to be between 37.7 and 37.6 °C and humidity between 56.3 and 55.7 %. The achieved hatching rate by the incubator was 90%. Since development is a required order and because its constant goals always pour into serving the matter concerned and raising its efficiency and since the air can be more efficiently distributed and directed by using the internal duct system. Furthermore, by bending this duct, the flowed air's velocity can be lessened toward the eggs within the hatcher, making it easier to regulate the pressure across the entire system. So, the objectives of this study are:

1. Manufacture a local incubator for hatching poultry eggs from low-cost local materials.
2. Determine suitable operating parameters such as temperature, humidity, and turning eggs that affect the performance of the incubator with constant other factors.
3. Evaluate the local incubator from an economic standpoint.

2. MATERIALS AND METHODS

The incubator was locally manufactured and the initial experiments were conducted in Agricultural and Bio-systems Engineering Department, Faculty of Agriculture, Damietta University, Egypt, for hatching poultry eggs based on an internal duct system. The practical experience was carried out during the year 2024 to evaluate the performance of the manufactured local incubator for poultry eggs to raise production efficiency in a sustained manner and increase the quality and quantity of production.

2.1. Materials

2.1.1. The used egg: poultry eggs (Dokki breed) used in this study were bought from the Animal Production Research Station Poultry Branch, Taftish El-Sirw village, Faraskour town, Damietta Governorate, Egypt. The used eggs were inspected and graded to exclude those that were cracked and the eggs polluted were cleaned before being incubated.

2.1.2. The manufactured incubator:

The manufactured hatching incubator consists of the following main parts: hatchery box, humidification unit, turning unit and control panel, as shown in **Fig. (2.1)**.

Fig.(2.1): 3D drawing of the manufactured incubator.

A. Hatchery box:

The hatchery box made of sandwich panel with a thickness (5 cm), has dimensions of (95×85×120 cm) for length, width and height and also has a door with dimensions of (85×110 cm) for length and height, respectively, to close the hatchery box tightly so that there is no wasted heat or humidity; it is closed with a screw, and it has an observer window with a diameter of 6 cm to follow the hatching process without having to open the door during the hatching period. The hatchery box consists of three main parts, as follows:

1. Heating chamber

The heating chamber is the upper part of the hatchery box, with dimensions of (85×70×30 cm) for length, width, and height, respectively. The heating chamber is powered by an electric heater (main heater). It also is provided a bulb (secondary heater) to work the same function as the first, too; if the temperature of the hatchery is not raised in record time, a malfunction occurs, or the first stops suddenly at any moment. The heating chamber has a hole in each side of its 3 cm diameter to expel out the chamber’s overheated air and maintain the atmosphere of the incubator for hatching eggs suitably without problems, as shown in **Fig. (2.2)**.

2. Hatching chamber

The hatching chamber is the lower part of the hatchery box, with dimensions of (70×55×80 cm) for length, width, and height, respectively. The hatching chamber has a retention fan of power 22 W to get out extremely hot air. And also has an LED bulb to improve the performance of productive chicks, as shown in **Fig. (2.2)**.

3. The middle part

The middle part designed as a U-inverted-shaped letter. The horizontal part of it, with dimensions of (70×55 cm) for length and width, serves as a dividing line between two chambers for hatching and heating. And the two sides bend as heat passages, with dimensions of (70×15×65 cm) for length, width, and height, respectively, as shown in **Fig. (2.2)**.

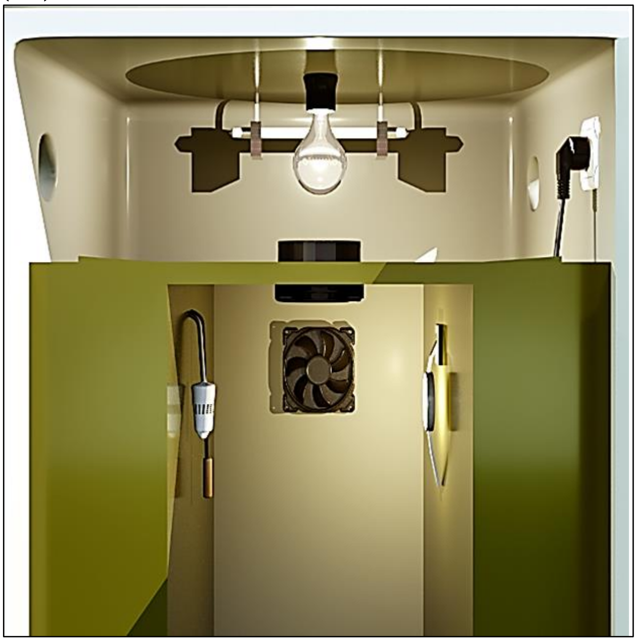

Fig.(2.2): 3D drawing of the hatchery box parts.

B. Humidification unit:

The humidification unit is powered by an electrical humidifier and put in a pan that consists of a float valve, linked to a water tank by a snout to keep the level of water in the suitable range, as shown in **Fig. (2.3)**.

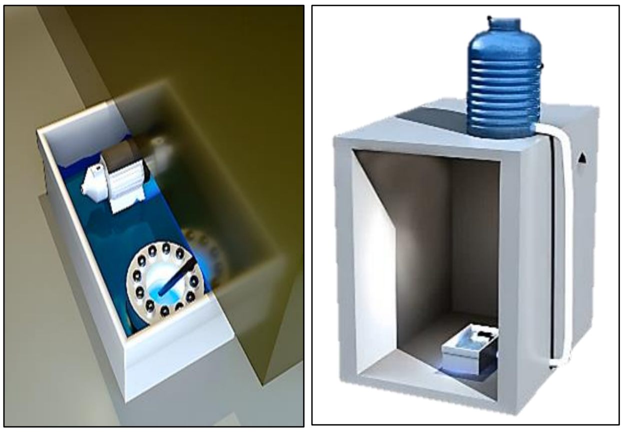

Fig.(2.3): 3D drawing of the humidification unit.

C. Turning unit:

The turning unit is powered by an electric motor of power 14W that is installed above the unit chassis of size (48.5×34.5×68 cm), which has four trays with a capacity 76 eggs of each. The electric motor transmits its rotation motion to the egg trays left and right using a gear with a diameter of 3 cm and a V-shaped chain installed on the sides of the first tray, as shown in **Fig. (2.4)**.

Fig.(2.4): 3D drawing of the turning unit.

D. Control panel:

The control panel consists of an intelligent microcontroller of the digital model XM-18z with an accuracy of the temperature of ±0.1°C, an accuracy of the humidity of ±3%, and made in China, suitable to control and regulate the incubator's options, as shown in **Fig. (2.5)**.

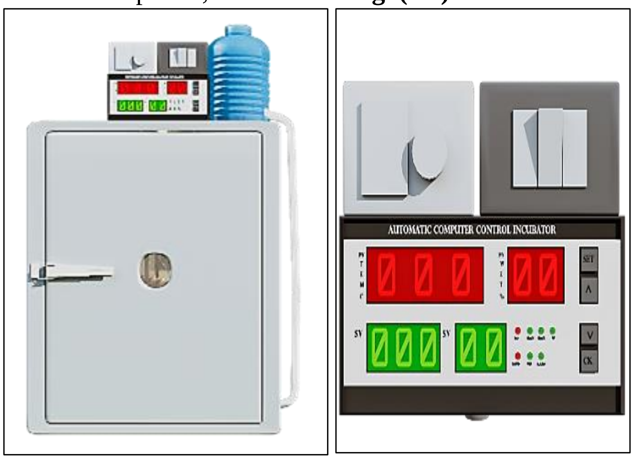

Fig.(2.5): Photo of the control panel.

2.1.3. Instruments:

To perform the functions of the hatching process, several measurements were used as follows:

- **Digital scale**

A digital scale made in China, model SF-400 with a measuring range of 0–10 kg and an accuracy of ±1 g was used to weigh the incubated eggs and productive chicks, as shown in **Fig. (2.6)**

Fig.(2.6): Digital scale.

- **Clamp meter**

A clamp meter made in China, weight 20 g, LED digital display, corded electric, and with measuring range of 0-600V and 0-100A was used to accurately read voltage and current, as shown in **Fig. (2.7)**.

Fig.(2.7): Clamp meter.

- **Hatching tray**

A hatching tray made in China, made of High-Density Polyethylene (HDPE), with dimensions 50×36×8 cm, weight 0.6 kg, with a capacity of 88 eggs, detachable, and high temperature resistance was used to receive the incubated eggs until hatching, and that at the last three days in the hatching period, as shown in **Fig. (2.8)**.

Fig.(2.8): Hatching tray.

2.2. Methods

2.2.1. Experimental conditions:

The fertilized eggs were put into the incubator manually and then exposed to some factors such as heat, humidity, lighting, turning, and ventilation. At that time, the incubator became a suitable medium that provided the appropriate conditions automatically for embryonic development inside the fertilized eggs until the chicks hatched.

2.2.2. Study variables:

The performance of the local poultry incubator was experimentally evaluated under the following conditions:

- Three levels of temperature (37, 37.5 and 38 °C).
- Two levels of humidity (50 and 55 %).
- Two levels of egg turning (12 and 24 times per day).

Those experimental conditions, the following coefficients were fixed:

- Ceasing to turn for the first and last three days of hatching.
- Sustaining lighting every 12 hours.
- Gradually increasing the humidity level in the final three days of hatching period.
- Non-ventilating for the first ten days, starting ventilation on the eleventh day at a rate of 30 seconds per two hours and progressively increasing until the hatching is complete.

2.3. Measurements

2.3.1. Engineering measurements

In order to elect the appropriate operational parameters for the hatching process, it was necessary to determine the following engineering measurements:

2.3.1.1. Incubator productivity:

The incubator productivity can be calculated by dividing the number of hatched eggs by the period consumed in the hatching process as in the following equation **Riaz *et al.*, (2021)**.

$$I_P = \frac{N_e}{T}, \text{chick/day} \ldots\ldots (1)$$

Where:

I_P = Incubator productivity, chick/day,

N_e = Number of hatched eggs, chick.

T = Period consumed in the hatching process, day.

2.3.1.2. Incubator efficiency (hatching ratio):

The incubator efficiency can be calculated as a percentage ratio by dividing the number of hatched chicks by the number of fertilized eggs as in the following equation **Amin, (1994)**.

$$\eta_H = \frac{N_c}{N} \times 100, \% \ldots\ldots (2)$$

Where:

η_H: Incubator efficiency (Hathability rate), %.

N_c: Number of hatched chicks.

N: Number of fertilized eggs.

2.3.1.3. Required power:

The required power was calculated by the following equation **Ashby, (1988)**.

$$P_o = \sqrt{2} \times \cos\varphi \times I \times V, W \ldots\ldots (3)$$

Where:

P_o: Power required, W.

$\sqrt{2}$: Coefficient current two phase (being equal 1.41).

$\cos\varphi$: Power factor (being equal to 0.7).

I: Current intensity, Ampere.

V: Voltage, (220 V).

2.3.1.4. Specific energy consumed:

The specific energy consumed can be calculated by dividing the power required for hatching process by the incubator productivity as in the following equation **Awady *et al.*, (2003)**.

$$E_{sp} = \frac{P_o}{I_P}, \text{W. day/chick} \ldots\ldots (4)$$

Where:

E_{sp}: Specific energy consumption, W. day/chick.

2.3.1.5. Operational cost:

The operational cost required for the hatching process can be calculated by dividing the hourly cost by the incubator productivity as in the following equation **Awady *et al.*, (2003)**.

$$C_{op} = \frac{C}{I_p}, \text{L.E/chick} \ldots\ldots (5)$$

Where:

C_{op}: Operational cost, L.E/chick.

C: Hourly cost, L.E/h.

2.3.1.6. Incubator hourly cost:

The cost per hour of hatching process is calculated from the following formula by **Awady, (1978)**.

$$C = \frac{P}{h}\left(\frac{1}{a} + \frac{i}{2} + t + r\right) + (W.e) + \frac{m}{700}, \ldots\ldots (6)$$

Table (2.1): Analyze the hourly cost of the local incubator.

Item	Vale	Unit
C=Hourly cost	0.62	L.E/h
P = Price of incubator	8000	L.E
h =Yearly working hours	8600	h/year
a = Life expectancy of an incubator	7	Year
i = Interest rate/year	10	%
t = Taxes, overheads ratio	6	%
r = Repairs and maintenance ratio	8	%
W = Power of motor	0.014	kW
e = Hourly kW price	1.44	L.E/kW.h
m = Monthly average wage	200	L.E/month
700 = Monthly working hours	700	h/month

2.3.1.7. Payback period:

The payback period of the incubator is estimated by using the straight forward formula, **Kamble *et al.* (2013)**.

$$P_A = \frac{I}{E}, \text{period} \ldots\ldots (7)$$

Where:

P_A: Payback period of the incubator.

I: Investment of the incubator, L.E.

E: Hatching period net cash revenue, L.E/period.

2.3.2. Biometrics measurements

To ensure the production of high-quality chicks, it was necessary to determine the following biometrics measurements:

2.3.2.1. Non-defect birds:

The non-defect birds can be calculated as a percentage ratio by dividing the number of birds by non-defect to the total number of chicks hatched as in the following equation **Riaz *et al.*, (2021)**.

$$N_D = \frac{N_b}{T_c} \times 100, \% \ldots\ldots (8)$$

Where:
N_D : Non-defect birds, %.
N_b : Number of birds with non-defect, chick.
T_c : Total chicks hatched, chick.

2.3.2.2. Chick yield:

The chick yield can be calculated as a percentage ratio by dividing the chick weight by the egg weight as in the following equation **Jabbar and Ditta, (2017)**.

$$C_Y = \frac{C_w}{E_w} \times 100, \% \quad .....(9)$$

Where:
C_Y : Chick yield, %.
C_w : Chick weight, g.
E_w : Egg weight, g.

3. RESULTS AND DISCUSSIONS

3.1. Incubator productivity:

The incubator productivity is affected by some factors such as hatching temperature, humidity level and numbers of turning times per day. Concerning to the effect of hatching temperature on incubator productivity, the results in **Fig. (3.1)** show that the incubator productivity was in the high values at hatching temperature of 37.5°C recorded 11.24 and 12 chick/day, while the lower and the higher hatching temperature of 37 and 38°C decreased the incubator productivity to 9.29 and 10.1, to 9.9 and 10.48 chick/day at number of times turning 12 and 24 times per day, respectively and humidity level of 55%.

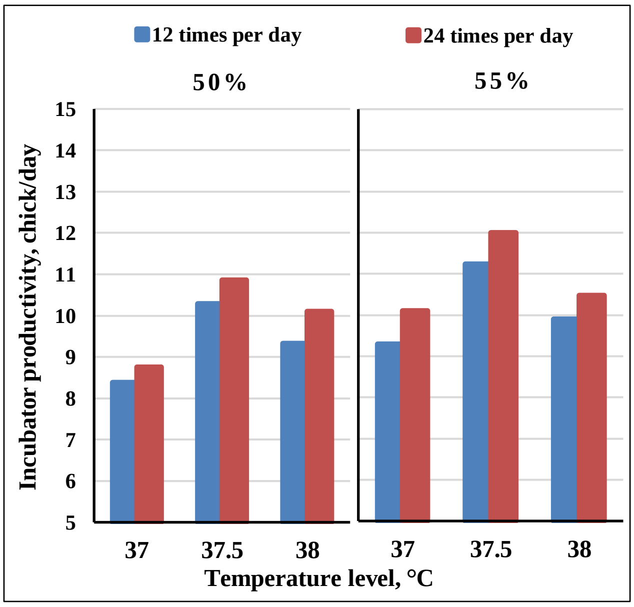

Fig.(3.1): Incubator productivity at temperatures, humidity levels and number times of turning.

These results show that the highest productivity is at a temperature of 37.5 °C. The difference between incubator productivity was due to embryonic development, which varies depending on hatching temperature degrees. A decrease in the hatching temperature to less than 37.5°C causes less rapid embryonic development than the normal rate, while an increase in the hatching temperature to more than 37.5 °C causes more rapid embryonic development than the normal rate, which anyway causes embryonic death; therefore, productivity decreases. These results agree with **(Abd El-Mottaleb, 2010)**. As related to the effect of the number of times turning on the incubator productivity, data in **Fig. (3.1)** show that, increasing the number of times turning from 12 to 24 times per day leads to increase the incubator productivity from 9.29 to 10.1, from 11.24 to 12 and from 9.9 to 10.48 chick/day at hatching temperature 37, 37.5 and 38, respectively and humidity level of 55%. These results show that the highest productivity is at numbers of turning times 24 times per day because increasing the number of times turning prevents the adhesion of the embryo to the shell and helps in proper embryonic development. As related to the effect of the humidity on incubator productivity, **Fig. (3.1)** show that, increasing humidity level from 50 to 55% leads to increase the incubator productivity from 8.76 to 10.1, from 10.86 to 12 and from 10.1 to 10.48 chick/day at different hatching temperature of 37, 37.5 and 38°C, respectively and the number of times turning 24 time per day. These results show that the highest productivity is at humidity level 55%. A decrease in the humidity level leads to increased loss of water from inside the incubated egg, which causes hardening of its outer shell so, it leads to embryonic mortality without hatching. These results agree with **(Abd El-Mottaleb, 2010)** and **(Adegbulugbe *et al.*, 2013)**.

3.2. Incubator efficiency (hatching ratio, %):

The incubator efficiency is affected by number of fertilized eggs and number of hatched chicks which affected with the parameter mentioned in (incubator productivity title). Concerning to the effect of hatching temperature on incubator efficiency, the results in **Fig. (3.2)** show that the incubator efficiency was in the high values at hatching temperature of 37.5°C recorded 88.06 and 98.44%, while the lower and the higher hatching temperature of 37 and 38°C decreased the incubator efficiency to 78.31 and 84.13, to 81.25 and 84.62% at number of times turning 12 and 24 times per day, respectively and humidity level of 55%. These results show the hatching temperature of 37.5°C gave the highest number of hatched chicks, resulting in the highest percentage of incubator efficiency, with an increase rate of 17.54 and 27.04% compared with the traditional and thermochemical incubators used by **(Hassan *et al.*, 2021)**.

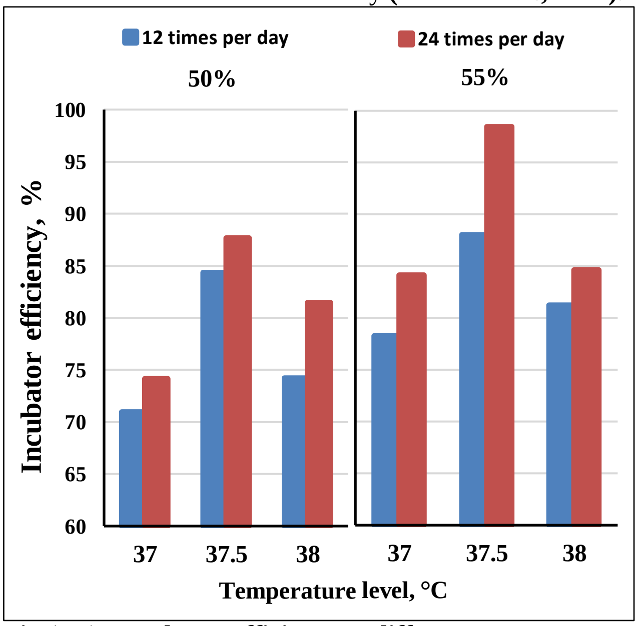

Fig.(3.2): Incubator efficiency at different temperatures, humidity levels and number times of turning.

The high of a manufactured incubator efficiency (98.44%) may be attributed to the air direction system (duct system), giving good air direction and reduction of air pressure. As related to the effect of the number of times turning on the incubator efficiency, data in **Fig. (3.2)** show that, increasing the number of times turning from 12 to 24 times per day leads to increase the incubator efficiency from 78.31 to 84.13, from 88.06 to 98.44 and from 81.25 to 84.62% at hatching temperature 37, 37.5 and 38°C, respectively and humidity level of 55%. These results show the number of times turning for the eggs of 24 times per day gave the highest number of hatched chicks, resulting in the highest percentage of incubator efficiency, with an increase rate of 6.6% compared with the incubator used by **(Oliveira *et al.*, 2020)**. As related to the effect of the humidity on incubator efficiency, **Fig. (3.2)** show that, increasing humidity level from 50 to 55% leads to increase the incubator efficiency from 74.19 to 84.13, from 87.69 to 98.44 and from 81.5 to 84.62% at different hatching temperature of 37, 37.5 and 38°C, respectively and the number of times turning 24 time per day. These results show the level humidity of 55% gave the highest number of hatched chicks, resulting in the highest percentage of incubator efficiency, with an increase rate of 8.97% compared with the automated incubator used by **(Sunday *et al.*, 2020)**.

3.3. Energy consumed:

The incubator's energy consumed is highly affected by the incubator productivity, which affected with the parameter mentioned in (incubator productivity title) and the power required, which affected by the limits were represented in the calculated equation from **Awady, (1978)**. Concerning to the effect of hatching temperature on energy consumed, the results in **Fig. (3.3)** show that the incubator energy consumed was in the low values at hatching temperature of 37.5°C recorded 15.57 and 14.58 W.day/chick, while the lower and the higher hatching temperature of 37and 38°C increased the incubator energy consumed to 18.84 and 17.33, to 17.68 and 16.7 W.day/chick at number of times turning 12 and 24 times per day, respectively and humidity level of 55%.

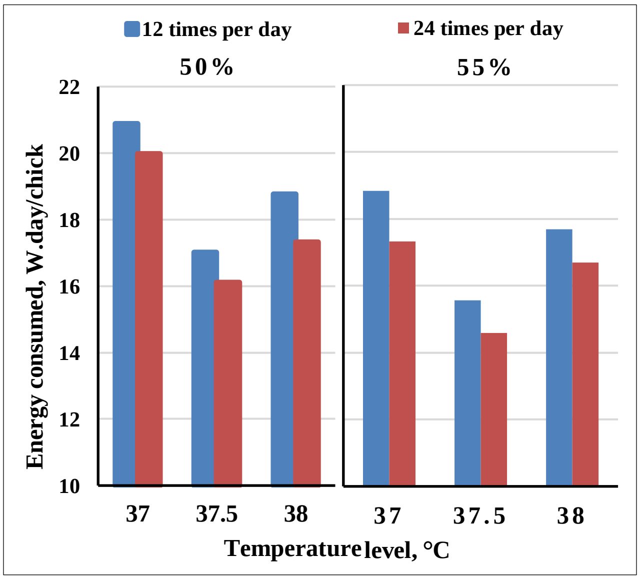

Fig.(3.3): Energy consumed at different temperatures, humidity levels and number times of turning.

As related to the effect of the number of times turning on the energy consumed, data in **Fig. (3.3)** show that, increasing the number of times turning from 12 to 24 times per day leads to decrease the energy consumed from 18.84 to 17.33, from 15.57 to 14.58 and from 17.68 to 16.7 W.day/chick at hatching temperature 37, 37.5 and 38°C, respectively and humidity level of 55%. As related to the effect of the humidity on energy consumed, **Fig. (3.3)** show that, increasing humidity level from 50 to 55% leads to decrease the energy consumed from 19.98 to 17.33, from 16.11 to 14.58 and from 17.33 to 16.7 W.day/chick at different hatching temperature of 37, 37.5 and 38°C, respectively and the number of times turning 24 time per day.

3.4. Operation cost:

The incubator's hatching operation cost is highly affected by the incubator productivity, which affected with the parameter mentioned in (Incubator productivity title), and also affected with price of the used eggs, price of the incubator, yearly working hours, life expectancy of the incubator, interest rate/year, wage for labor, taxes, overheads ratio, repairs and maintenance ratio, monthly working hours, motor power, hourly kW price and monthly average wage. The fixed and variable costs were represented in from **Awady, (1978)** equation.

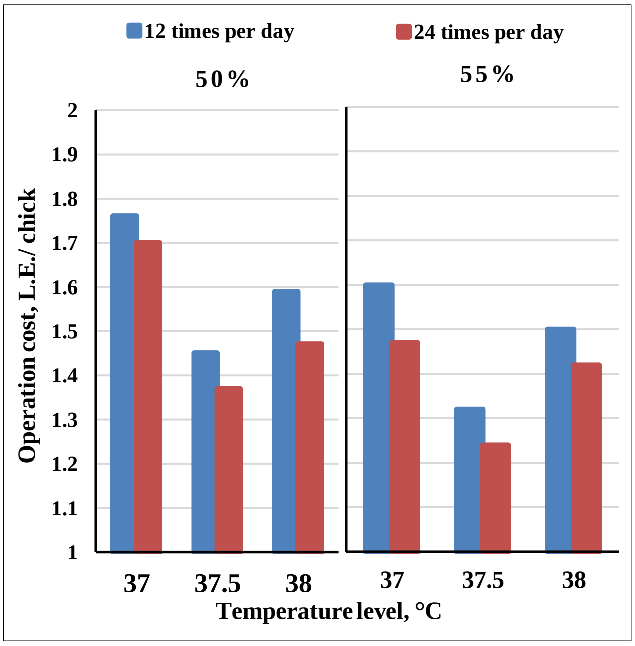

Fig.(3.4): Operation cost at different temperatures, humidity levels and number times of turning.

Concerning to the effect of hatching temperature on operation cost, the results in **Fig. (3.4)** show that the incubator operation cost was in the low values at hatching temperature of 37.5°C recorded 1.32 and 1.24 L.E/chick, while the lower and the higher hatching temperature of 37 and 38°C increased the incubator energy consumed to 1.6 and 1.47, to 1.50 and 1.42 L.E/chick at number of times turning 12 and 24 times per day, respectively and humidity level of 55%. As related to the effect of the number of times turning on the incubator operation cost, data in **Fig. (3.4)** show that, increasing the number of times turning from 12 to 24 times per day leads to decrease the energy consumed from 1.6 to 1.47, from 1.32 to 1.24 and from 1.50 to 1.42 L.E/chick at hatching temperature 37, 37.5 and 38°C, respectively and humidity level of 55%. As related to the effect of the humidity on incubator operation cost, **Fig. (3.4)** show that, increasing humidity level from 50 to 55% leads to decrease the operation cost from 1.70 to 1.47, from 1.37 to 1.24 and from 1.47 to 1.42 L.E/chick at different hatching temperature of 37, 37.5 and 38°C, respectively and the number of times turning 24 time per day.

3.5. Non-defect birds:

The non-defect birds are affected by some factors such as different hatching temperatures, humidity levels, and numbers of turning times. Concerning to the effect of hatching temperature on non-defect bird percentage, the results in **Fig. (3.5)** show that the non-defect bird percentage was in the high values at hatching temperature of 37.5°C recorded 96.61 and 100%, while the lower and the higher hatching temperature of 37 and 38°C decreased the non-defect bird percentage to 91.79 and 96.23, to 86.54 and 90.91% at number of times turning 12 and 24 times per day, respectively and humidity level of 55%. These results show that the highest non-defect bird number or percentage is at a temperature of 37.5 °C.

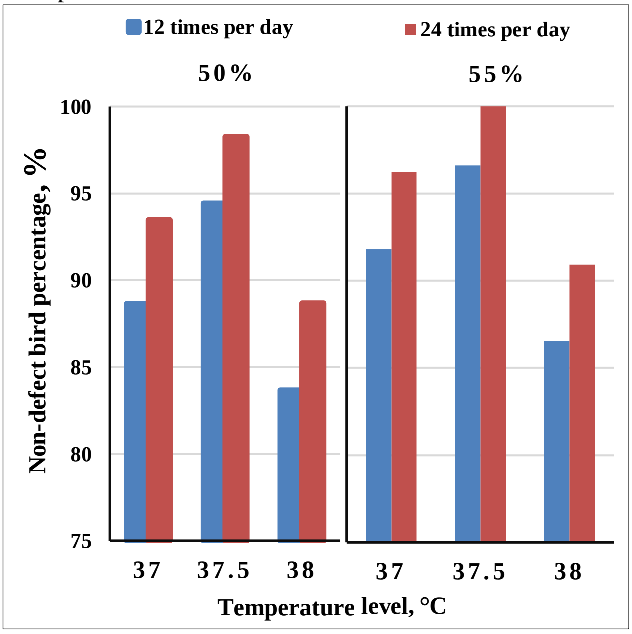

Fig.(3.5): Non-defect birds at different temperatures, humidity levels and number times of turning.

A decrease below the hatching temperature of 37.5 °C causes delayed hatching and deformation of chick, as an increase in the hatching temperature of 37.5 °C causes early hatching and deformation of chick. These results agree with **(Abd El-Mottaleb, 2010)** and **Dutta and Anjum (2021)** who reported that overly high or low temperatures during incubation can lead to a number of problems, including early hatching, undeveloped or crippled chicks, and dead embryos at an early stage. As related to the effect of the number of times turning on the non-defect bird percentage, data in **Fig. (3.5)** show that, increasing the number of times turning from 12 to 24 times per day leads to increase the non-defect bird percentage from 91.79 to 96.23, from 98.61 to 100 and from 86.54 to 90.91% at hatching temperature 37, 37.5 and 38°C, respectively and humidity level of 55%. These results show that increasing numbers of times turning from 12 to 24 times per day leads to increase non-defect bird percentage. As related to the effect of the humidity on non-defect bird percentage, **Fig. (3.5)** show that, increasing humidity level from 50 to 55% leads to increase the non-defect bird percentage from 93.48 to 96.23, from 98.25 to 100 and from 88.68 to 90.91% at different hatching temperature of 37, 37.5 and 38°C, respectively and the number of times turning 24 time per day. These results showed that increasing level humidity from 50 to 55 % leads to increase non-defect bird percentage.

3.6. The chick yield:

The chick yield is affected by the egg weight and the chick weight which affected with some factors such as hatching temperature, humidity level, and numbers of turning times per day. Concerning to the effect of hatching temperature on chick yield, the results in **Fig. (3.6)** show that the chick yield was in the high values at hatching temperature of 38°C recorded 75.16 and 76.24 %, while at the lower hatching temperature of 37 and 37.5°C decreased the chick yield to 65.32 and 66.39, to 67.95 and 68.04 % at number of times turning 12 and 24 times per day, respectively and humidity level of 55%. The results revealed that chick yield increased with an acceptable rate when hatching temperature was increased from 37 to 37.5°C, which led to the production of chicks of ideal quality, capable of consuming feed and water. Although, by increasing the temperature to 38°C, the chick yield heads to increase, too, but this increase is unacceptable, leading to producing a lazy group of chicks that are unable to consume feed and water. As related to the effect of the number of times turning on the chick yield, data in **Fig. (3.6)** show that, increasing the number of times turning from 12 to 24 times per day leads to increase the chick yield from 65.32 to 66.39, from 67.95 to 68.04 and from 75.16 to 76.24 % at hatching temperature 37, 37.5 and 38°C, respectively and humidity level of 55%.

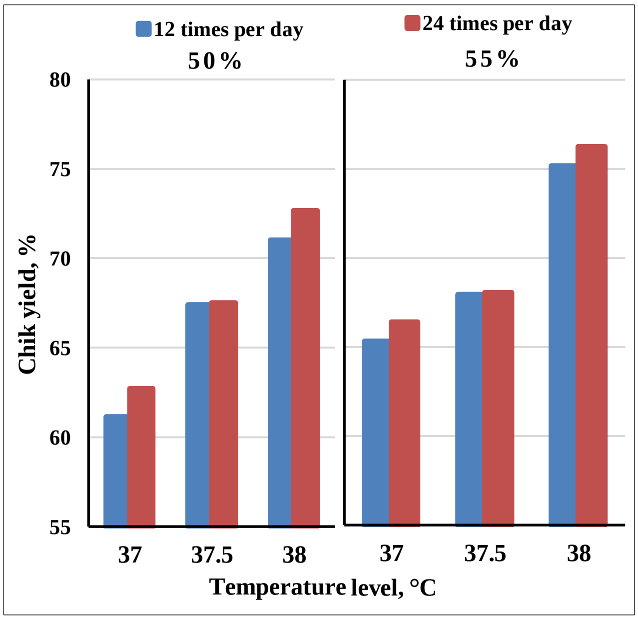

Fig.(3.6): The chick yield at different temperatures, humidity levels and number times of turning.

As related to the effect of the humidity on chick yield, **Fig. (3.6)** show that, increasing humidity level from 50 to 55% leads to increase the chick yield from 62.73 to 66.39, from 67.52 to 68.04 and from 72.65 to 76.24 % at different hatching temperature of 37, 37.5 and 38°C, respectively and the number of times turning 24 time per day. These results show that the highest chick yield percentage are at a humidity level of 55%.

3.7. Payback period:

The payback period of the incubator is affected by the investment of the incubator and the hatching period net cash revenue, as shown in the **table (3.1).**

Table (3.1): The production value for the incubator.

Production value, (L.E/hatching period)						
Investment of the incubator				Net cash revenue		
Eggs			Incubator	Chicks		
Amount, Egg/period	Unit cost, L.E/egg	Total cost, L.E/period	Unit cost, L.E.	Amount, chicks/period	Unit cost, L.E/chick	Total cost, L.E/period
304	7.5	2280	8000	252	19	4788
Total		10280		Total		4788

Concerning to the payback period for hatching poultry eggs by the manufactured incubator, the production value for the manufactured incubator in **Table (3.1)** shows that the payback period was found to be 2.15 hatching periods, or 48 days. That is, within a month and eighteen days, or about three periods maximum. The hatching in the manufactured incubator seems to be economical because the cost of hatching is very cheap and available throughout the year; thus, no additional expenditure was incurred for the hatching process.

4. SUMMARY AND CONCLUSSION

The experimental work was carried out to manufacture and evaluate a local incubator's performance for hatching poultry eggs. From the obtained results for hatching poultry egg breed Dokki, it could be concluded that:

1. The highest values of incubator productivity and incubator efficiency were 12 chick/day and 98.44%, respectively at temperature of 37.5°C, humidity level of 55%, and 24 turning times per day.
2. The lowest values of incubator productivity and incubator efficiency were 8.38 chick/day and 70.97%, respectively at temperature of 37°C, humidity level of 50%, and 12 turning times per day.
3. The highest values of energy consumed and operating cost were 20.88 W.day/chick and 1.76 L.E/chick, respectively at temperature of 37°C, humidity level of 50%, and 12 turning times per day.
4. The lowest values of energy consumed and operating cost were 14.58 W.day/chick and 1.24 L.E./chick, respectively at temperature of 37.5°C, humidity level of 55%, and 24 turning times per day.

That is why the study recommends the use of the locally manufactured incubator for hatching poultry eggs under the following conditions:

1. Hatching temperature of 37.5 °C.
2. Humidity level of 55%.
3. Number of times turning of 24 times per day.

Taking into account the mentioned fixed factors, to give the following suitable values:

-The highest productivity: 12 chick/day.
-The highest efficiency (hatching ratio): 98.44%.
-The lowest energy consumed required for hatching:14.58 W.day/chick.
-The lowest operating costs of the incubator:1.24 L.E./chick.

Moreover, to achieve the highest quality of chick produced with the following values:

-The highest percentage of chicks without defects: 100%.
-The ideal value for the chick yield: 68.04%.

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CONFLICT OF INTEREST:

The authors declare that they have no conflict of interest.

AUTHORS CONTRIBUTION:

All authors developed the concept of the manuscript. Aburyaq wrote the manuscript and achieved the experimental work and measurements. All authors checked and confirmed the final revised manuscript.

5. REFERENCES

Adegbulugbe, T. A., Atere, A. O. and Fasanmi, O. G. (2013): Development of an automatic electric egg incubator. International Journal of Scientific & Engineering Research, 4(9), 914-918.

Ahmed, N. M. (2023): Analysis of the strengths and weaknesses of poultry meat foreign trade in Egypt. Alexandria Science Exchange Journal, 44(3), 465-471.Awady, M. N. (1978): Tractor and farm machinery. Text book, Faculty of Agriculture, Ain-Shams University. Pp: 164-167.

Al-Mottaleb, A. (2010): Developing a local semi-mechanical incubator for minimum production cost. Misr Journal of Agricultural Engineering, 27(3), 943-961.

Amin, E. A. (1994): Development of a grading machine for some horticulture farm crops. J. Agric. Sci. Mansoura Univ., 19(7) :3139-3149.

Ashby, J. G. (1988): Power hydraulics. PAVIC publication.

Awady, M. N. (1978): Tractor and farm machinery. Text book, Faculty of Agriculture, Ain-Shams University, Pp: 164-167.

Awady, M. N., Yehia, I., Ebaid, M. T. and Arif, E. (2003): Development and theory of rice cleaner for reduced impurities and losses. Misr J. Agric. Eng., 20(4), 53-68.

Dutta, P., and Anjum, N. (2021): Optimization of Temperature and Relative Humidity in an Automatic Egg Incubator Using Mamdani Fuzzy Inference System. International Conference on Robotics, Electrical and Signal Processing Techniques (ICREST), pp. 12-16.

El-Sebaee, I. M. (2019): Development house incubator unit operated with renewable energy. Misr Journal of Agricultural Engineering, 36(4), 1249-1264.

Hassan, S. A., Mustafa, M. M., Abdo, M. S., and Attar, M. Z. (2021): Using Thermochemical Materials as a Heat Source for Poultry Egg Incubation. Arab

Universities Journal of Agricultural Sciences, 29(1), 243-262.

Jabbar, A., and Ditta, Y. A. (2017): Incubation duration of broiler breeder egg and post hatch performance. World's Veterinary Journal, (3), 83-88.

Kamble, A. K; Pardeshi, I. L; Singh, P. L. and Ade, G. S. (2013): Drying of chilli using solar cabinet dryer coupled with gravel bed heat storage system. Journal of Food Research and Technology. October-December, Vol. 1 Issue (2), Pp: 87-94.

Kommey, B., Akudbilla, D., Doe, G., and Amponsah, C. O. (2022): A low-cost smart egg-incubator. Sustainable Engineering and Innovation, 4(1), 22-33.

Oliveira, G. S., Dos Santos, V. M., Rodrigues, J. C., and Nascimento, S. T. (2020): Effects of different egg turning frequencies on incubation efficiency parameters. Poultry science, 99(9), 4417-4420.

Riaz, M. F., Mahmud, A., Hussain, J., Rehman, A. U., Usman, M., Mehmood, S., and Ahmad, S. (2021): Impact of light stimulation during incubation on hatching traits and post-hatch performance of commercial broilers. Tropical Animal Health and Production, 53, 1-8.

Sunday, A. A., Ogunbode, O. A., Babatunde, E. G., and Olalekan, A. M. (2020): Design and construction of automated eggs incubator for small scale poultry farmers. International Journal of Technical Research & Science, 5(8).

تصنيع وتقييم أداء حاضنة محلية لتفريخ بيض الدواجن

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أجريت هذه الدراسة لتصنيع وتقييم حاضنة محلية وذلك لتفقيس بيض الدواجن خلال عام 2024 وتم إجراء التجارب الأولية في قسم هندسة النظم الزراعية والحيوية بكلية الزراعة - جامعة دمياط. وقد نبعت فكرة هذه الدراسة من توافر مواد محلية الصنع ومدى إمكانية الاستفادة منها كخامات رخيصة، وكذلك التغلب على المشاكل التي تواجه عملية التفريخ كانخفاض نسبة الفقس وعدم جودة الكتاكيت المنتجة بالإضافة إلى التكلفة العالية، وقد روعي في هذه الدراسة رفع كفاءة ونسبة الفقس وزيادة جودة وكمية الكتاكيت المنتجة بالإضافة إلى تقليل تكلفة عملية التفريخ. المكونات الرئيسية لحاضنة تفريخ بيض الدواجن المصنعة محلياً: تتكون هذه الحاضنة من أربعة أجزاء أساسية هي: صندوق التفريخ، وحدة الرطوبة، وحدة التقليب ولوحة التحكم. تم تقييم أداء الحاضنة المصنعة وفقاً للمعاملات التالية: ثلاثة مستويات من درجة الحرارة: 37 و37.5 و38 درجة مئوية. مستويان من الرطوبة: 50 و55%. مستويان من عدد مرات تقليب البيض في اليوم: 12 و24 مرة في اليوم. أظهرت النتائج أن أنسب المعاملات التشغيلية لتفريخ بيض الدواجن باستخدام حاضنة التفريخ المصنعة محلياً هي: درجة حرارة 37.5 درجة مئوية، رطوبة 55٪ وعدد مرات تقليب للبيض 24 مرة في اليوم حيث حققت هذه المعاملات أعلى كفاءة (نسبة الفقس) وإنتاجية للحاضنة وأقل طاقة مستهلكة وتكاليف تشغيلية: 98.44٪، 12 كتكوت / يوم، 14.58 وات.اليوم/كتكوت و 1.24 جنيه / كتكوت، على التوالي. ولهذا توصي الدراسة باستخدام حاضنة تفريخ بيض الدواجن المصنعة محلياً في ظل الظروف التالية: درجة حرارة 37.5 درجة مئوية. مستوي رطوبة 55%. عدد مرات تقليب 24 مرة في اليوم.

الكلمات المفتاحية: الحاضنة، التفريخ، نسبة الفقس، نظام الدكت، تكاليف التشغيل، درجة الحرارة.