Arid Zone Journal of Engineering, Technology and Environment. October, 2007; Vol.5, 45-53
Copyright© Faculty of Engineering, University of Maiduguri, Nigeria.
Print ISSN: 1596-2490, Electronic ISSN: 2545-5818
www.azojete.com.ng

DEVELOPMENT AND PERFORMANCE EVALUATION OF A KEROSINE HEATED CHICKEN EGG INCUBATOR

Ndirika, V.I.O.[1] and S.A. Ademoye[1]

Abstract

A kerosene-heated chicken egg incubator of 160 eggs capacity was developed and its performance evaluated based on incubation temperatures, relative humidity, period of incubation and percentage of eggs hatched. The results revealed that the average incubation temperature and relative humidity obtained were 38.68 ^{0}C and 58.16% respectively at average ambient conditions of 27.2^{0}C temperature and 84.68% relative humidity. Also, the incubation temperature and incubation relative humidity at different levels of tray varied between 36.8-40.9^{0}C and 46.5 – 67% respectively, but the differences in their mean values at different egg tray levels were not statistically significant at 5% level.

Up to 80% of the eggs were hatched over a period of 22 days at hatching temperature of 37.5^{0}C within ambient conditions of 27^{0}C temperature and 68.5% relative humidity. The results obtained were found to conform with the results obtained from already established research works on natural incubation method for chicken.

1. Introduction

Chicken egg is oval in shape and contains white albumen and a yolk which are enclosed by a shell. Egg is very important to life because of its nutritional value. It contains albumen which is an essential protein constituent having a weight of about 12% of its total weight (Ademoye, 1998). For fertilized egg, the yolk can develop into a chick under the application of certain range of heat.

Oluyemi and Robert (1988) defined incubation as the management of a fertilized egg to ensure the satisfactory development of the embryo inside into a normal chick. Incubation can be achieved by natural or artificial methods. In the natural method, it takes the chicken about 20 – 21 days to hatch them. The artificial method is achieved by the application of designed equipment to aid hatching and heat is supplied by electrical or non-electrical means. Due to frequent electric power failure and lack of access to electricity in the rural areas, alternative sources of energy such as kerosene and charcoal, should be considered in the design of non-electrical incubators. Some of the problems often reported with the use of alternative heating sources are in the areas of temperature control, turning of eggs, air pollution and contamination of eggs and economic considerations. The major factors limiting the effective operation of the incubator such as temperature control, turning of egg, air pollution and contamination of egg have been reported from some test reports by Osuigwe and Nwachukwu (1994), Shimonyan (1997) and Ademoye (1998). A good kerosene incubator would be capable of eliminating the electricity difficulties encountered. The specific objectives of this study were to develop a chicken egg kerosene incubator and to evaluate the performance of the incubator

[1] Department of Agricultural Engineering, Inst. Of Agric. Res. Ahmadu Bello University, Zaria, Nigeria

2. Materials and methods

2.1 Design consideration

The parameters considered in the design of the incubator were air temperature and control, heat transfer, relative humidity, capacity and turning mechanism for eggs. The design parameters were established as recommended by other researchers (Ademoye, 1998; Ogundipe & Oni, 1986) as follows:

(i) A capacity of 160 eggs for a small household
(ii) An incubation temperature of 34.9^0C
(iii) An average Relative humidity of 57.5%
(iv) A turning angle of 75^0.

2.2 Description of the incubator

The incubator consists of four basic components, namely the egg tray, water trough, turning device and a hollow pipe. The assembly and isometric views of the incubator are presented in Figures 1 and 2 respectively. The eggs to be hatched were placed on the trays having a maximum capacity of 160 eggs. It was constructed from wood and aluminium wire net. The tray dimensions were 480mm x 200mm x 50mm. A rectangular mild steel water trough of dimension 430mm x 200mm x 20mm was placed at the bottom of the incubator to raise the humidity. The turning device, extending from the top to the bottom of the incubator, anchors the egg tray and allows for their tilting up to 75^0. It was constructed from 40mm diameter hollow steel pipe and had overall length of 560mm. A hollow tube that extends from the outside into the incubator served as a duct for transmission and distribution of hot air to the incubator. The pipe was constructed from 40mm diameter hollow steel pipe with overall length of 1180mm. The entire structure was covered with a wooden frame work. The outer surfaces were covered with particle board as insulating materials.

Fig. 1: Assembly Drawing of the Incubator

Figure 2: Isometric Drawing of the Incubator

2.3 Working principle

Hot air produced as a result of kerosene combustion was conveyed from the outside into the incubator through the pipe. The pipe was positioned at the bottom and the heat distributed uniformity by natural convection. The heat energy is used by the eggs on the tray for embryo development. Turning was achieved by pulling and pushing the steel rod attached to the turning device that extends to the outside at an angle of 75^0. The temperature was manually controlled by varying the distance between the heating source and the transmission pipe with the ventilation hole remaining open. The ventilation hole allows fresh air to flow into the incubator.

2.4 Experimental procedure

Wet and dry bulb thermometers (ranging between 0 – 100 ^{0}C) were installed inside the incubator to determine the temperature and relative humidity of the incubating chamber, while a thermocouple was used to measure the temperature of the heating source, which ranged between 0-720 ^{0}C.

The period for turning of eggs, temperature reading and control, opening and closing of ventilation hole were determined using a stop watch. A preliminary experiment was conducted without eggs inside the incubator in order to determine the temperature required and how it will be controlled. Some 160 eggs obtained from the National Animal Production Research Institute (NAPRI) and were placed in the incubator and heated. The stove produced hot air which was transferred into the incubator through steel pipe with the ventilation hole closed for 40 minutes in order to attain the required temperature. The ventilation hole was then opened and the distance between the stove and the pipe was varied to control the temperature. The eggs inside the incubator were turned 4 times daily at regular intervals. The following parameters were evaluated in the experiment; hatchability, hatching temperature, hatching period, incubation temperature and incubation relative humidity. Hatchibility was obtained using the following relation (Oluyemi and Robert, 1998).

$$\text{Hatchibility (\%)} = \frac{\text{Number of live hatching after five days}}{\text{Initial number of hatching}} \times 100$$

The results obtained with the kerosene incubator were compared with that of natural incubation. Variation of average incubation temperatures and the relative humidities at different levels of egg tray were monitored.

3. Result and discussion

3.1 *Incubation temperature and relative humidity*

The average incubation temperature and relative humidity obtained with the kerosene incubator were 38.68^{0}C and 58.16^{0}C respectively at ambient conditions of 27.2^{0}C temperature and 84.64% relative humidity (Table 1). The coefficient of variation of the incubation temperature was 2.77% while that of that of the relative humidity was 8.91%. This implies that the variation of the data obtained over the test period for both incubation temperature and relative humidity were not significant at 5% level. The average incubation temperature and relative humidity fall within the range of 38 – 41.71^{0}C and 50-60% obtained by Sonaiya *et al* (1995) with natural incubation method (Table 2).

Table 3 shows that there were variations of incubation temperature and relative humidity at different levels of egg tray but were not significant at the 5% level. The incubation temperature obtained at different levels of egg tray varied between 36.8 – 40.9^{0}C, while the relative humidity varied between 46.5 – 67%. The variation of temperature and relative humidity during the period of incubation are presented in Figures 3 and 4. The incubation temperatures were higher than the room and ambient temperatures at different periods of incubation. The highest value of the average incubation temperature (40.9^{0}C) was attained on the 5th day at 29^{0}C room temperature and 27^{0}C ambient temperature. The relative humidities obtained at these temperatures were 59.8% and 81.5% in the incubator and the ambient respectively.

Table 1: Average incubator and ambient conditions over the test period

Period (days)	Ambient Temperature (^{0}C)	Incubation Temperature (^{0}C)	Incubation R.H(%)	Ambient R.H. (%)	Room Temperature (^{0}C)
1	28.0	38.3	58.0	91.0	25.6
2	28.0	39.3	60.5	91.5	25.4
3	27.0	39.1	57.8	87.5	24.0
4	28.7	39.0	59.2	88.5	26.6
5	27.0	40.9	59.8	81.5	29.0
6	27.0	39.1	58.3	80.0	28.1
7	25.0	38.9	55.3	81.0	26.5
8	28.0	38.0	60.0	81.0	25.9
9	26.5	38.0	56.0	88.5	24.4
10	29.7	38.3	59.9	88.0	26.3
11	26.5	38.0	57.8	93.5	25.5
12	27.5	40.5	58.3	79.5	27.4
13	27.5	39.3	59.8	84.0	26.9
14	26.0	39.1	59.7	84.0	27.2
15	26.5	37.8	57.0	73.0	25.8
16	27.0	38.9	62.0	84.0	27.0
17	26.5	39.5	59.5	81.5	27.8
18	27.5	37.0	57.5	85.5	23.5
19	27.5	39.8	60.5	92.5	25.2
20	27.5	38.5	58.2	87.5	25.4
21	26.5	36.6	67.0	91.0	25.4
22	27.0	37.0	37.5	68.5	28.9
Mean	27.2	38.68	58.16	84.68	
SD	0.97	1.07	5.18	6.24	
CV(%)	4% (n.s)	2.77%(n.s)	8.91% (n.s)	7.4% (n.s)	

SD = Standard deviation; CV = Coefficient of Variation; n.s. = not significant

Table 3: Variation of average incubation temperature and relative humidities at different levels of Egg tray

Tray levels	Incubation temperature ^0C	Incubation relative humidity, %
1	40.9	59.8
2	40.5	58.3
3	39.4	46.5
4	39.0	59.2
5	38.0	60.0
6	37.8	57.0
7	37.0	57.5
8	36.8	67.0
Mean	38.68	58.16
SD	1.53	5.65
CV(%)	3.96% (n.s)	9.72% (n.s)

n.s. : not significant

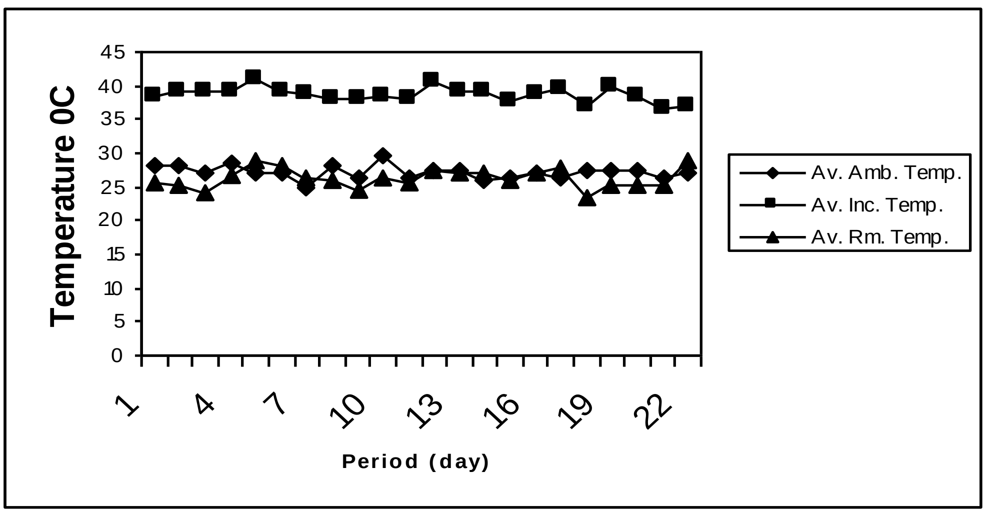

Figure 3: Variation of temperature with the period of incubation

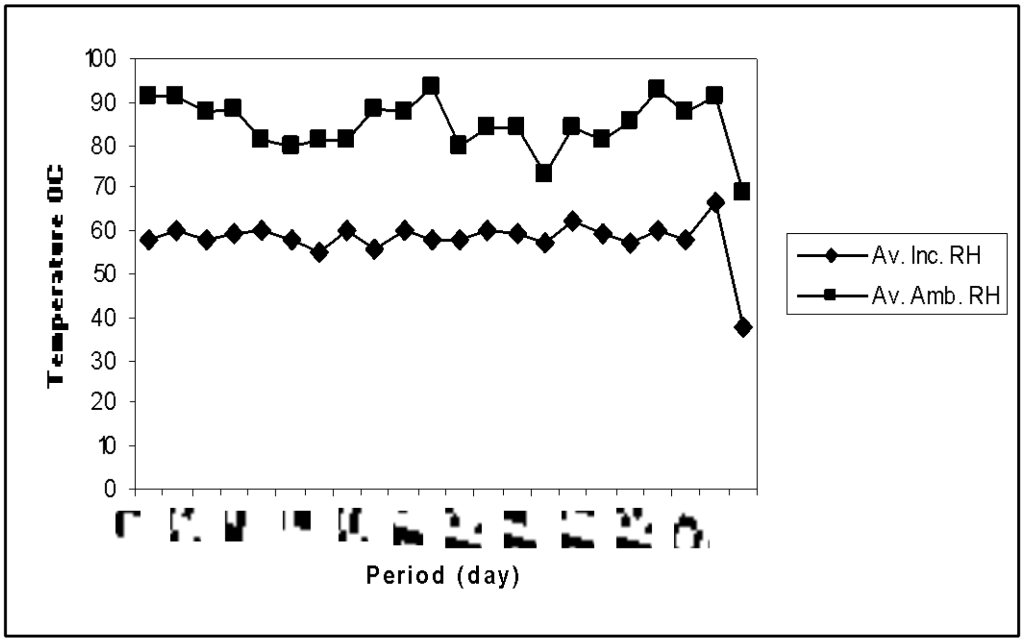

Figure 4: Variation of relative humidity with the period of incubation

3.2 *Hatchibility, hatching, temperature and hatching period*

Hachibility of 80% was obtained and that compared favourably with the value obtained by Dafwang *et al.* (1998) with natural incubation method (Table 2). A hatching period of 22 days was obtained in this study. This is slightly longer than the maximum 21 days or natural method (Sonaiya *et al.*, 1995). The slight variation may be due to temperature fluctuation during the experiment.

Figure 5 shows the effect of the distance between the pipe and the heat source on the incubation temperature. The incubation temperature decreases with increase in distance between the pipe and the heating source. The incubation temperature was higher without the eggs than with the eggs inside it. Incubation temperatures of 40.5 and 38 ^{0}C were attained at a distance of 8.5cm without and with eggs respectively. The temperature was lower (40 ^{0}C) even at a shorter distance of 6.5 cm with eggs. This could be due to the utilization of hot air for the development of the embryo inside the eggs.

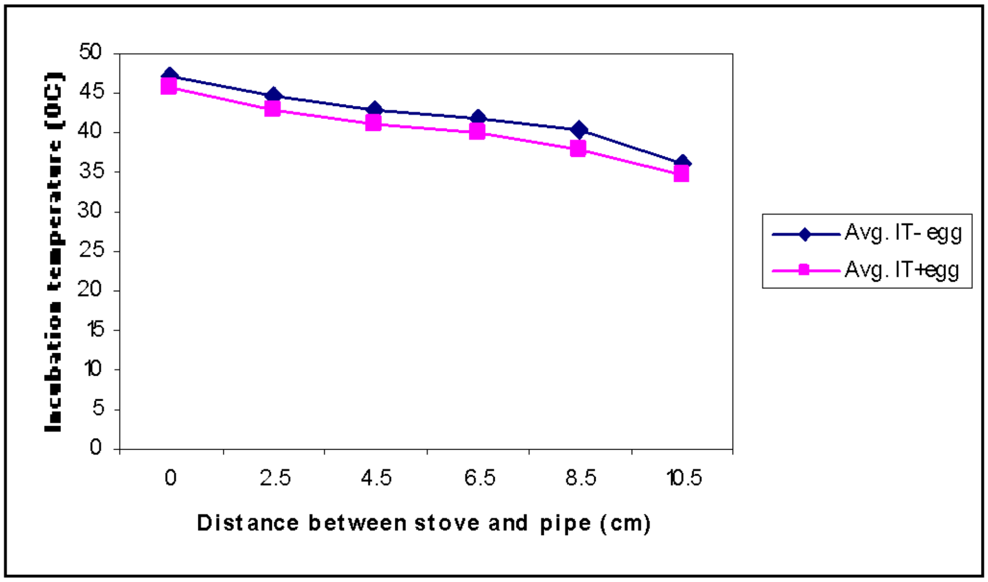

Figure 5: Effect of distance between the stove and the pipe on the incubation temperature

4. Conclusion

A kerosene incubator was fabricated and tested. The performance of the incubator was satisfactory when compared with natural method. The 160egg incubator has an incubation temperature and R.H of 38.68^{0}C and 58.16% respectively and hatchability of 80%. The incubator is recommended for use in school laboratories for demonstration and teaching purposes and for small household uses.

References

Ademoye, S. A. (1998). *Design and construction of incubator*. Unpublished B. Eng. Thesis, Department of Agricultural Engineering, Ahmadu Bello University, Zaria, Nigeria.

Dafwang, I.I.; J. Y. Odiba and E. I. Ikani (1998). Hathery Management Handboook *Extension Bulletin* No. **79**. A Publication of NAERLS/ABU, Zaria, pp. 8-12.

Oluyemi, J. A. and F. A Robert (1988). *Poultry Production in warm wet climate*. Macmillan Publishers Limited, London and Basing Stroke.

Osuigwe, D. I. and V. N. Nwachukwu (1994). Portable incubator for small scale fish hacteries. *Journal of Agricultural Technology* **2**:1-5.

Pgundipe, S. O. and O. O. Oni (1986). *Poultry breeding and hatching management*. Poultry research programme. National Animal Production Research Institute (NAPRI), Ahmadu Bello University, Zaria, Nigeria pp. 2-5.

Shimoyan, K. J. (1997): *Design and Construction of Incubator*. Unpublished M.Sc. Thesis. Department of Agricultural Engineering, Ahmadu Bello University Zaria, Nigeria.

Sonaiya, E. B.; G. Agbede, I. K. Odubore, A. O. Abdullahi and J. A. Oluyemi (1995). Evaluation of local poultry ecotypes for productivity and disease resistance. *Proc. Of the 20th annual Conference of NSAP* held at Fed. University of Technology Minna 26-30 March, 1995.