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Low-Cost Design of Poultry Egg Incubator with W1209 Digital Temperature Controller.

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Abstract: *The progression of poultry egg incubation procedures through the years as a function of scientific and technological developments. Currently, the main directions of research are with the management of eggshell temperature with the combining effects of variables that control the process of incubation. In this context, an efficient and low-cost incubator was designed with a W1209 digital temperature controller with other cost-effective materials. Fifteen layers of eggs of nearly uniform weight were subjected to incubation over the natural period of 21 days at 38^{o}C. The chicks were completely hatched and matured after the last 6 hours of 21 days incubation periods.Economic implications of the 15 eggs capacity incubator were calculated to be #15,000.00 (Forty-one thousand and five hundred nairas only) [38.95 United States Dollar].These further emphasize the significance of temperature, relative humidity, and egg turning and positioning in the entire systems of incubation.*

Keywords: Poultry egg, low-cost incubator, temperature, humidity &W1209 digital temperature controller.

1.0 INTRODUCTION

Through the previous 50 years, the global yearly production of meat has nearly doubled from 78 million tons in 1963 to 308 million tons in 2015, accomplishing solid growth from around 205 million tons between 1995 and 2015 to 319 million tons [1] and over the last two decades, poultry meat production increased by nearly 108%, correlating to a 36% increase in its share of the total production of meat [2].The production of poultry meat is projected to double by 2020-2022, due to increasing population growth and consumption of meat per capita. Under this trend, global poultry meat consumption is calculated at 128 million tons by 2022[3]. To fulfill this high demand for poultry meat, hatcheries have to ensure maximum production of chicks, and this not only requires the incubation of more fertile eggs. Today, hatcheries need to achieve high product performance in a sustainable way, which, in general opinions, involves optimizing the hatchability of healthy chicks with high survival levels and the full distribution of their genetic potential for growth in any circumstances. Acquired scientific knowledge on incubation over the years highlights the physiological variables in which the eggs are subjected before and during incubation [2].Incubation is the management of a fertilized egg to ensure the successful growth of the embryo within the fertilized egg into a healthy chick, and the task of preserving the fertilized eggs moist so that the embryo can develop properly into a chick either by natural or artificial methods [4].In natural incubation, the bird provides the conditions required for the exceptionally few eggs she lays by sitting on the eggs periodically until they hatch in an open area, whilst an artificial incubator is a compartment where temperature, moisture, and airflow are manipulated to hatch a relatively high number of eggs than what a single hen can handle at a time [5]. Artificial egg incubation systems have undergone a technological, cultural, and social transition in the last few years. Spectacular scientific and technological advances have facilitated the transformation from manual incubation to large incubation machines and hatcheries, which incubate a much larger number of less labor-intensive egg incubations and production in a year-round [2]. Conversely, to sustain a sufficient incubation situation, this incubation revolution induced costs associated with the construction of more sophisticated incubators with operational expenses in terms of energy and water.Coal, oil, gas, or electricity typically provides the heat needed for incubation. In small incubators, approximately 58 percent relative humidity is held at 120^{o}F (38 to 39^{o}C) till the eighteenth day of incubation during which the humidity increases up to 70 percent and the temperature dropped to 96^{o}F (36^{o}C) before the chick is hatched.

An incubator must be able to control variables like temperature and humidity and enable air renewal and egg flipping, ensuring optimal atmospheric conditions for embryonic maturity with a purpose of achieving high hatchability of stable chicks which is closely correlated with the sustainability and success of individual chicks in the field [3]. Incubators worthy of incubating various numbers of eggs of different bird species are available commercially, with more or less complex control systems for temperature, humidity, ventilation, and egg-turning. New state of the art commercial hatcheries are fitted with automated systems that monitor all physical incubation factors like egg turning, environmental temperatures determined by thermosensors, air relative humidity and loss of egg water determined by weight sensors on the egg tray; and air quality (O_2 and CO_2 levels)[3]. However, as Paniago 2005 has already pointed out, despite the technological advancements of modern incubation machines, incubation success still depends on the nature of labor, both within and outside the hatcheries, which involves training [3]. Incubators are typically installed in corners of rooms away from walls to allow sufficient ventilation and provide the incubator operator with enough workspace. Hatching eggs degrade with time, and should usually not be kept for more than seven days before incubation is set.The storage temperature at which embryonic development is aborted should be about12.5^{o}C [3]. To avoid dehydration of the shells, relative humidity should not be less than 80 percent [3]. If the temperature for storage is too low (-2^{o}C) the blastoderm can freeze [3]. The selected eggs should be of the natural shape, weighing approximately 56.7g, with decent shell texture, and free of faults [5]. Effort should be made to avoid hatching eggs from being injured in the nest, but if this occurs, they should be scraped clean rather than washed, which is harmful since water may produce contagious microorganisms and therefore opens up washing normally opens the openings on the shell of the eggs that cause rapid evaporation [4]. However, egg color does not affect hatchability, while coloring with extreme length can suggest calcium deficiency in the shell [4]. At a macroscopic point of view, while the external and egg environments appear to be entirely separate, the eggshell contributes in and enables interactions between these two conditions, as defined by the relationship between temperature, relative humidity, ventilation (air quality) and incubating eggs, which are important for the success of embryonic and fetal growth[3]. The physical interactions between the egg and the outside world (the incubator's egg and air) comprise heat conduction and the exchange of O_2, CO_2, and water [3]. Egg specifications such as size, composition and shape, and thickness of the eggshell, porosity, heat, water vapor and conductance, the rate of embryo metabolism and physical incubation conditions as well as pre-incubation conditions can cause deviations from the optimal values of these physical agents [3]. These deviations can interfere with, or even impede, in-ovo growth, result in adverse consequences on hatchability and hatching quality and subsequent results, phenotype, and survival. Hence, because of these, the need for a compact and low-cost incubator to increase and improve the hatchability of human consumption eggs with economic sustainability

2.0 MATERIALS AND METHODS

Transparent Polyethylene Terephthalate plastic container of 70cmin height, breadth of 100cm and width of 65cm. was acquired (incubator), 12V DC exhaust fan, 9V, 1A DC power supply adapter, UPS, cellophane tape, synthetic gum, smaller plastic container, W1209 Digital temperature controller and 35W soldering iron heating element.

2.1 Assembling the incubator.

The 12v DC exhaust fan and the heating element were attached by directly facing the interior of the plastic incubator that was as well perforated for good ventilation; with connection to the power adapter and the temperature controller (sensor was perforated into the incubator). A smaller plastic container for water (humidifier) was perforated on top of its lid, to monitor the humidity not less and more than 60%. The incubator was sealed, powered and programmed by the temperature controller between 37.7-39^{o}C.

2.2 Setting the eggs for incubation

Fifteen fresh and pre-weighed chicken eggs were carefully arranged within with humidifier at the corner of the incubator. It was then covered, as they were overturning and rotating three times daily for eighteen days.

3.0 RESULTS AND DISCUSSION

Table 1. Weights of the fifteen samples of chicken eggs for incubation

Egg Number	Weight (g)
1	55.54
2	55.50
3	55.62
4	56.54
5	56.53
6	56.52
7	56.60
8	57.34
9	57.45
10	55.55
11	55.61
12	56.52
13	56.34
14	56.60
15	55.61

Table 2. Descriptive statistics for the fifteen eggs

Actual mean	56.26± 0.43
Median	56.52
Mode	56.52
Range	1.95
Maximum	57.45
Minimum	55.50

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Figure 1. (70×100 ×65) cm^3 transparent plastic container.

Figure 2.D.C Exhaust fan (12v).

Figure 3.Power supply adapter (9v, 1A).

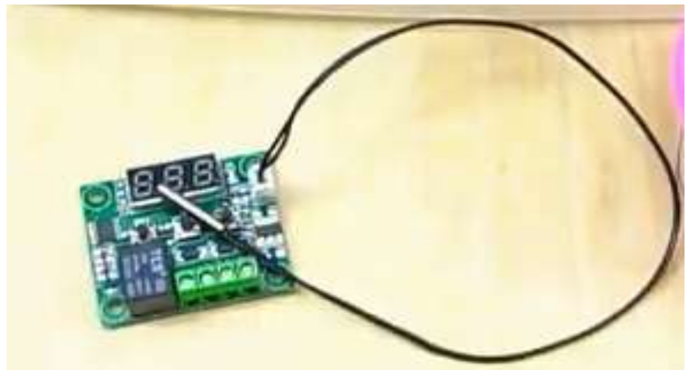

Figure 4.Digital temperature controller (W1209).

Figure 5. Soldering iron heating element (35w)

Figure 6.Smaller plastic container (humidifier)

Figure 7.Layer's eggs (15)

Figure 8. Activated low cost egg incubator

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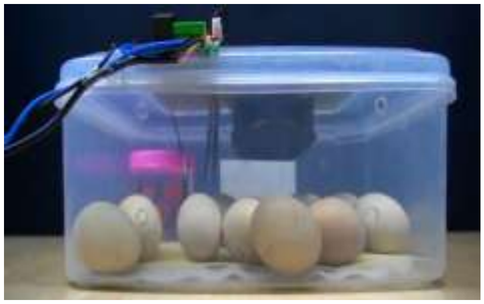

Figure 9. Eggs under incubation

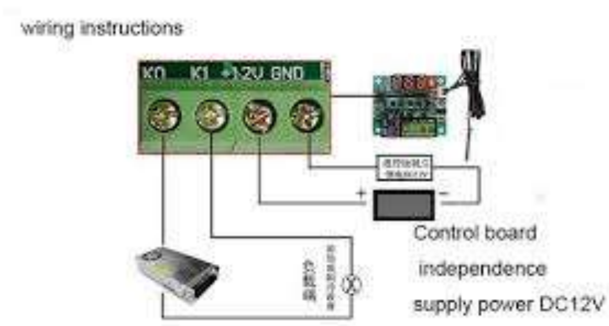

Figure 10. Integrated wiring module of W1209 digital temperature controller with other components.

Table 3.W1209 function settings reference table

W1209 Function setting reference table			
CODE	Function	Setting range	Initial value
P0	Heating / cooling	C/H	C
P1	Hysteresis setting	0.1-30	2
P2	Set the temperature upper limit	110℃	110
P3	Set the temperature lower limit	-50℃	-50
P4	Temperature Calibration	-7℃ /7℃	0
P5	Delay time	0-600s	0
P7	High temperature alarm	0-110℃	OFF
P8	Reset	C/H	C

Table 4.Hatching degree after 20 and 21 days

Period (days)	Period(hours)	Observation
20	24	All the eggs were still intact without cracks
21	First 6hrs	Only one egg was seen hatched with a chick
	Second 6hrs	2 eggs were hatched with chicks
	Third 6hrs	5 eggs have been hatched with chicks
	Fourth 6hrs	9 eggs were hatched with chicks

Figure 11. First 6 hours of the completed incubation period (21days)

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Figure12. Second 6 hours.

Figure 13.Third 6 hours.

Figure 14.Fouth 6 hours

Figure 15. The final stage of incubation

This low-cost incubator was made of Polyethylene Terephthalate plastic container with a height of 70cm, breadth 100cm and width 65cm. The exhaust fan (figure 2) was attached to circulate air, which ensures uniform temperature factor within the incubator, avoiding any form of temperature gradients throughout the incubator. Some quantities of water in a small container were placed at the corner of the incubator (figure 6). Layers eggs of different weights were carefully arranged within the incubator (figure 7). The electrical power supply to the incubator was through the mains (figure 3). Meanwhile, alternative means of power (UPS) were made accessible. The temperature controller (figure 4) was fixed outside (Figure 10) of the incubator for the ease of operation. Table 1 displays the weights of the egg samples used for the project with the statistical descriptions (Table 2). Table 3 is the W1209 function settings reference table. Table 4, summarizes the stages and physical observations over a length of 21 days incubation periods.

Table 5. Economical implications of the incubator

S/N	ITEM	COST (#)
1	Transparent Polyethylene Terephthalate plastic container (70× 100 × 65)	300
2	Smaller Plastic Container	100
3	12V DC Exhaust Fan	1,500
4	9V, 1A DC Power Supply Adapter	1,000
5	Cellophane Tape	100
6	W1209 Digital Temperature Controller	1,500
7	35W soldering iron heating element.	400
8	UPS	10,000
9	Wires	100
	Total	15,000

4.0 CONCLUSION

Physical parameters concerning temperature and humidity especially are very critical for the development of poultry eggs into chicks. Similarly, the advancement in science and technology makes it very creative in designing and constructing a cost-effective poultry egg incubator. Hence In the light of this, job creation and economical developments through the value chain emanating from poultry products will be massive and encouraging in the nearest future.

5.0 REFERENCE

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