Small Scale Solar-Powered Brooder

N.P. Oputa[1]; Audu Ibrahim Ali[2]; E.C. Ugwuoke[1]; C.P. Ezeigwe[3]; and Muhammed Shaibu[2]

[1]Projects Development Institute (PRODA), Enugu, Nigeria.
[2]Department of Mechanical Engineering, Federal Polytechnic, Idah, Nigeria.
[3]Science Laboratory Technology, Federal Polytechnic, Oko, Anambra State, Nigeria.

E-mail: emmychyugwuoke@yahoo.com

ABSTRACT

For thriving poultry production in developing countries such as Nigeria, where the electricity supply has remained inadequate and unreliable, alternative methods of meeting the energy needs in agriculture and in the poultry industry specifically, have to be evolved. These alternative energy needs cannot be over-emphasized, for energy is required at various stages of poultry production especially during brooding processes. A small-scale solar brooder was developed and tested with 10 chicks over a period of 10 days. The physical and biological performance evaluation were conducted for the solar powered brooder.

The ambient temperature variation ranges from 28°C to 34°C. Also the brooding chamber temperature varied from 31°C to 34°C. The four weeks brooding period was done from the first day of November to the last day of November. This time was selected because it is expected that rainfall will be scanty and adequate solar radiation will be recorded at the time. The weight of the 10 day old chicks varied from 27g to 30g. The average weight was measured and obtained to be 28.3g. At day 15, the average weight was recorded to be 526.4g. The average weight increased to 762.2g at day 30.

(Keywords: solar brooder, chicks, temperature, humidity, poultry farming)

INTRODUCTION

Brooding in poultry farming refers to the care of chicks in the first four to six weeks of their life [1]. This involves supply of adequate food, water as well as keeping the environmental conditions at certain values. This means keeping temperature, humidity, ventilation, and light at levels comfortable for the chicks [1].

Chicks, before four weeks old, cannot effectively regulate their body temperature unlike adult birds and hence artificial heating is required to maintain this temperature [2]. The temperature in the brooder enclosure should be between 30°C and 35°C for the first week, 28°C and 30°C for the second week, 25°C and 28°C for the third week, and 20°C and 25°C for the fourth week [3], [4].

The temperature and humidity levels as required are important for proper chick growth. If the chick's body temperature is not maintained at the required level, the chicks will have poor growth, feed conversion, and increased susceptibility to disease [2]. In general, chick enclosures should be kept at a temperature starting at about 34°C and reduced gradually as the chicks grow up to 20°C after four weeks. The first week is the most important stage. Brooder heating has been found to be the biggest single energy item in broiler farming [5].

The optimum relative humidity in a brooder has been found to be between 50 and 70% [2]. Low relative humidity is associated with dusty conditions within the brooder. Dusty conditions result in respiratory infections while high humidity results in increased ammonia production. Ammonia production occurs due to the microbiological breakdown of fecal matter in the litter (wood shavings) [2]. Also, high relative humidity is known to promote the growth of harmful microbial organisms. If relative humidity exceeds 70% then it will create undesirable effects and RH below 50% creates dust in poultry house [6]. Ammonia gas has a negative impact on bird health and performance [2]. It impairs the immune system and increases respiratory diseases in the chicks therefore reducing the growth rate. Poor growth rates during the brooding period cannot be recovered.

Adequate ventilation is necessary to remove ammonia, hydrogen sulfide, dust, and odors. High ammonia levels result in poor growth and increased respiratory disease [7]. Ventilation also affects the relative humidity. Brooders should therefore be well ventilated However excess ventilation has the disadvantage of resulting in heat loss and results in increased energy requirements.

In large sophisticated farms, the above conditions are easily achieved by air conditioning. The chick houses are air conditioned using fans and heaters. However, in most small-scale farms in Nigeria, there are no facilities for air conditioning and therefore farmers use other brooding methods. In most cases the farmers aim to maintain only the required temperature. However, the methods employed do not create the strict conditions required throughout the brooding period. The temperature in these brooders vary from one area of the brooder to another, it also fluctuates. This results in high mortality of the chicks and also poor growth. It is therefore important that alternative methods should be developed to maintain the temperature in the brooder at the right level with minimal variation and fluctuation.

In this work, an attempt is made to review brooder types that could be used to provide the required temperatures and make it easier to maintain the ideal conditions for brooding. Further, floor heating can employ solar energy and also utilize hybrid systems that combine biomass, biogas, diesel, solar, LPG and natural gas.

The advantage of floor heating is that uniform temperatures can be maintained within the brooder. This system depends on conduction, radiation, and convection as means of heat transfer [6]. The brooder floor can also be kept dry – minimizing the wet conditions and heating can also be automated. The high heat capacity of the floor enables the temperature to be maintained for a long time without the heat source compared to other methods. It is in these respects that this type of heating procedure may benefit the brooding process in terms of adequate temperature conditions and overall cost reduction.

Nigeria is presently faced with the challenges of epileptic power supply from the national grid, economic meltdown, and a down-ward trend in the price of her crude oil resulting in mass unemployment, youth restiveness, armed robbery, kidnapping, and other numerous vices [8]. Experts from various fronts have made valuable suggestions on the way out of the woods. The most popular of these ideas and suggestions tend towards massive and aggressive agricultural development. The sustainability of any agricultural development effort is highly dependent on power and energy [8].

The Earth receives enormous amounts of radiant energy from the sun, which directly or indirectly sustains all living things (New Science Encyclopedia, 1989). The sun can potentially provide the equivalent of about 25,000 times the total amount of energy presently used from all other sources. However, only a very small fraction of this freely available energy is exploited through direct means for human use (UNESCO Report, 1979) [9].

Provision of heat energy for poultry production is a basic necessity for the survival and optimum performance of day-old chicks during the brooding period.

Solar Energy in Brooding

For successful poultry production in developing countries such as Nigeria, alternative methods of meeting the energy needs in the poultry industry have to evolve to create employment towards changing our communities [8].

Solar energy in brooding systems makes use of solar radiation which is converted into thermal energy to provide required warmth to the chicks. The heat obtained during the day is stored for use in the night period when there is no sunlight to supply heat to the brooding chamber or house. Solar energy would be an excellent source of sustainable power for poultry farmers in Nigeria because solar radiation is available all year round in the country which receives about 4.85×10^{12} kilowatts of energy from the sun every day, equivalent to about 1.082 million tons of oil per day [8].

Assessments have proved that the initial cost of installing a photo thermal system from poultry brooding can be recuperated within two years of energy savings.

The technology is environmentally sound because it does not pollute the atmosphere and it also drastically reduces the risk of fires. Solar powered poultry brooders have the following characteristics:

- They are economically viable.
- They use equipment that are relatively easy to construct and operate.
- They produce cost free energy.
- They improve the quality of chicks produced.
- They are relatively inexpensive to maintain.

Gas Brooder

A gas brooder uses LPG gas as a fuel for heating operation. If cost considerations are neglected then it can be most beneficial brooder as it installs with proper setup (sensors, exhaust system, control panel, etc.) [6]. As this is fully automated system there is no need of extra man power. Some limitations of this system are, initial and working costs are too high so cannot be affordable for small scale farmers. There is a problem of improper electric supply in rural areas, so it can cause stopping of system. Continuous increase in price of LPG gas cylinder affects working cost.

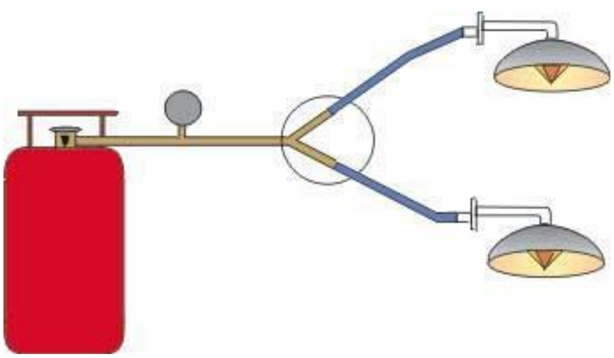

Figure 1: Gas Brooder [10, 6].

Radiant Tube Heater

Radiant tube is use for heating purpose. It covers large spaces with radiant heat. The system requires less amounts of electricity. Floor space isn't a requirement as the system is installed in the celling. A simple exhaust system can be use.

Disadvantages of this system are that overheating can occur. Temperature variation can also occur along tube length. Discontinuous power supply can cause problems with this type of system.

Figure 2: Radiant Tube Heater [11,6].

Solar Heating System

Black absorbers are used to concentrate sunlight which converts sunlight to heat. Due to the renewable source of energy this system is eco-friendly. Energy can be stored and used whenever it requires. But it has some limitations such as high initial costs, maintenance required, accessory costs, and temperature variations which may occur due to changes in climate [6].

Figure 3: Solar Heating System [12, 6].

Okolie Paul Chukwulozie concluded the following results in their work entitled; "Design for Temperature Controlled Solar Heated Chick Brooder":

1. For several chicks, the temperature required to maintain desired temperature is lower.

2. Chicks can keep warm each other.

3. Temperature control is required between 34°C to 24°C.

4. Heating is not required if temperature is maintained in the proper range.

5. Regulation required if temperature is near to the require temperature.

Under Floor Heating

This system depends on conduction, radiation, and convection as means of heat transfer. Under-floor heating systems use underground electric heating and underground pipes for heat transfer. This system requires external boiling and cooling system as it provides heating and cooling. But this system requires more space and has higher installation cost. [13]

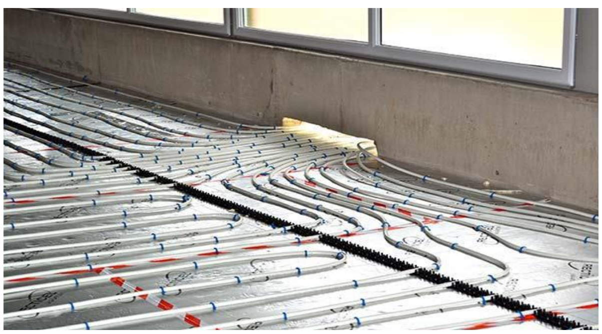

Figure 4: Under Floor Heating [14, 6].

Trombe Wall Poultry Chick Brooder

Trombe wall forms an integrated part of the house duly oriented south ward for maximum solar energy collection all year around. This is made of 0.22 m thick solid block to form the thermal storage system external surface of wall which is expose to environment is treated with black paint for the absorption of radiation energy from sun [6]. Glazing through the glass reduces excess heat loss from long wave radiation [15]

Kerosene Brooder

Kerosene brooders play important roles in rural and remote area. This system requires 40 lit kerosene units per day for approximately 1000 birds [6]. The lamps can create health issues for chicken. Also the availability of kerosene may create logistics problems in developing nations. Kerosene brooders are relatively high cost.

Pot Charcoal Brooder

In this brooder charcoal is used as a heat source which is applicable to remote and rural areas. Charcoal brooders are widely used since they are easily available and have low operating costs. In the economic sense, charcoal is a very efficient fuel. It burns easily and for longer periods.

Along with such benefits it carries some disadvantages. It creates smoke in high quantity which is harmful to chickens' health. During the rainy season there is a higher possibility that charcoal may get wet due to rain so proper care and storage is needed. Charcoal takes some time for initial heating.

Environmental Parameter

Relative humidity (RH), CO_2 and ammonia (NH_3) plays very important roles in the growth of chicken. Proper ventilation is required to control all of these parameters. If RH exceeds 70% then it will create undesirable effects. RH below 50% creates dust in poultry house. Modern techniques are trying to reduce heat losses for maintaining temperature of poultry farms. Due to this formation of CO_2 takes place. Gas heaters help in formation of CO_2 and also birds create their own CO_2. High levels of NH_3 create impacts on the growth of young chickens. It reduces the rate of weight gain of chicks. Different rates of NH_3 production in farm gives different rates of growth. Various factors affect the rate of production of ammonia (i.e., ambient temperature, ventilation rate, humidity, composition of food, etc.) [17].

Relative Humidity: Relative humidity of over 70% is undesirable and should be contained through use of ventilation. RH level below 50% result in higher production of dust and airborne microorganisms. During summer bird experience discomfort due to high relative humidity combined with high temperature [17].

Carbon Dioxide: Modern poultry housing is designed and constructed to reduce heat loss and improve energy efficiency but when combine with reduction in ventilation to prevent loss of heat energy this can result in increasing CO_2. Two main sources of CO_2 are from gas heaters and from the bird themselves [6].

Ammonia: Increases in NH_3 concentration levels in poultry can be caused by high moisture levels along with high temperatures which promote bacterial growth and cause organic material to decompose. NH_3 levels should not exceed

20ppm over 8hr period or 35ppm over in10 min period during poultry production cycle [6].

MATERIALS AND METHODS

Type T, Copper (+) Constantan (-), -184 to 371°C, was used. It is suitable in oxidizing, reducing, or inert atmospheres as well as vacuum. Moisture resistant and very stable. This type is best suited for low temperature service.

Methods

Physical and biological performance evaluations were conducted. The physical evaluation involves testing the long-term temperature readings of the brooding house and the breading wall using copper-constantan thermocouple wires connected to digital and locations. Mercury in glass thermometers were also positioned within and outside the brooder house for comparative readings. Readings of brooder temperature, and ambient temperature were recorded in degrees centigrade determined at two-hour intervals from 8am to 6pm and average mean value were recorded for a period of 7 days.

The physical performance of the house was tested some weeks before introduction of day-old chicks. Solar radiation and wind data from the period were obtained from the meteorological unit of the department of geography. The biological performance evaluation of the house involved testing with 10 broiler day-old-chicks for the brooding period (1st November 2017 – November 30th, 2017) and testing the efficiency of the brooding equipment. The second batch testing involved 20 broiler day-old-chicks introduction. The chicks were fed day and night using top starter broiler feed interchanged with vital starter feed. Good water fit for human consumption was given to the chicks. Disease prevention measures were taken as prescribed by a veterinarian from a Veterinary consultancy firm.

RESULTS AND DISCUSSION

The study was done in the year 2017 from 1st day of November to 30th day of November 2017. The month was chosen to ensure that adequate solar radiation was obtained and to remove irregularities in the result due to weather conditions. The small-scale solar brooder used for the studies was design for capacity of 20 chicks. It was meant to be used by peasant farms in the rural communities for either peasant purposes or household use. The ambient temperature variation ranges from 28°C to 34°C. Okonkwo et al. (2007) recorded the ambient temperature range between 18-37°C in their experiment. The maximum ambient temperature was recorded on the day 4 while the minimum ambient temperature was recorded on the day 7. The brooding chamber temperature varied from 31°C to 34°C. The temperature was achieved because of black paint at one side of the solar brooder. Ahiaba et al. (2013) indicated that the brooding chamber temperatures between 29°C to 38.5°C was maintained within the brooding chamber. Odo et al. (2016) examined physical performance of a brooder which shows that brooding temperature of the brooder ranges from 25°C to 38°C and relative humidity ranges from 30.00% to 82%.

Table 1: Average Mean Temperatures of the Various Components of the Brooding House.

Day	Ambient Temperature (°C)	Brooding Chamber Temp (°C)
1	33	34
2	30	32
3	30	33
4	34	35
5	29	32
6	32	34
7	28	31

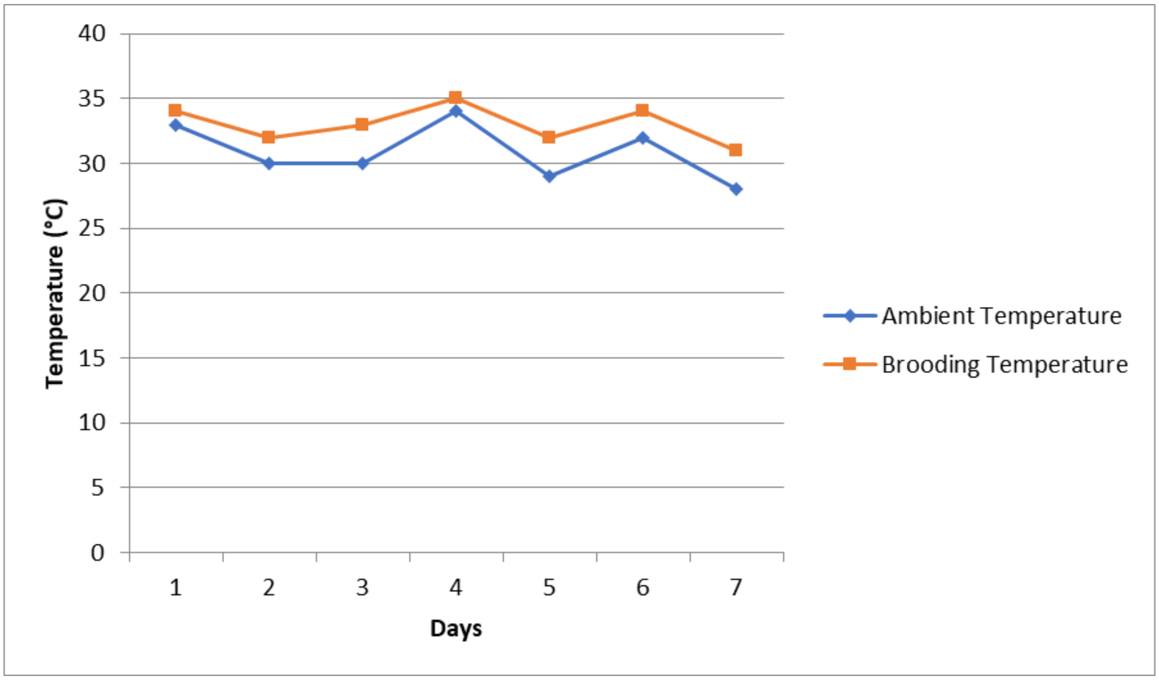

Figure 1: Ambient Temperature and Brooding Temperature Variations for 7 Days.

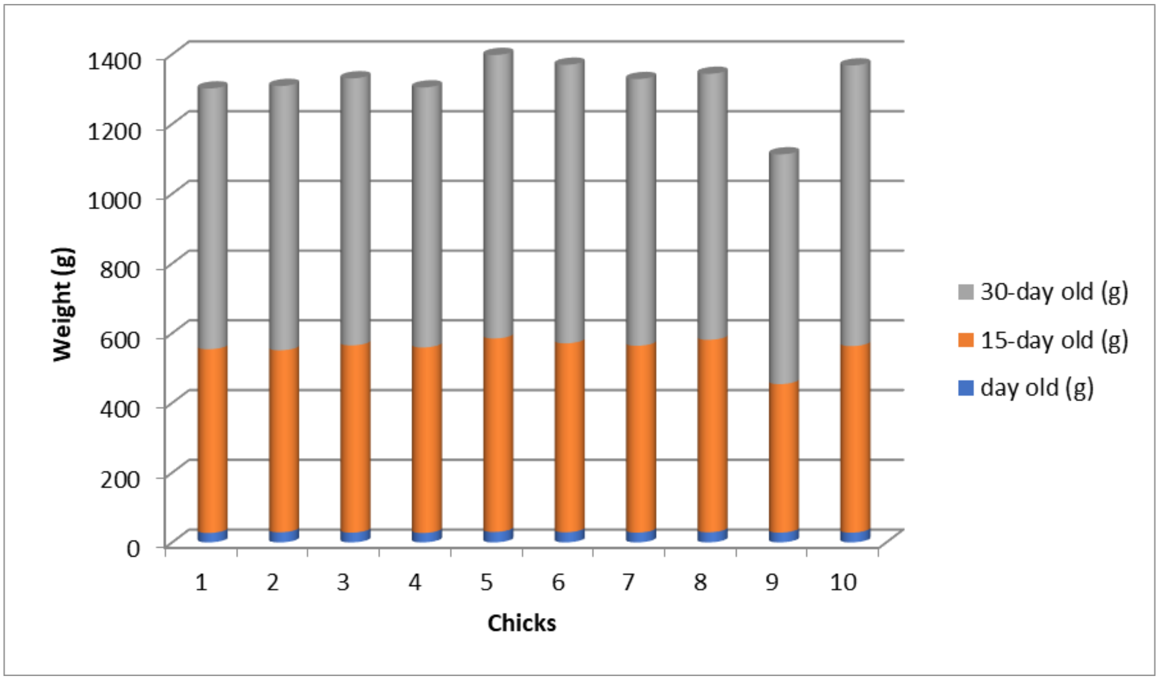

Figure 2: Weights of the Chicks at Day-1, Day-15 and Day-30.

Table 2: Weights of the Chicks at Day-1, Day-15 and Day-30.

Chicks	At day old (g)	At 15-day old (g)	At 30-day old (g)
1	27	527	748
2	29	522	758
3	28	537	766
4	27	532	746
5	30	555	813
6	29	542	799
7	28	536	765
8	29	552	763
9	28	426	659
10	28	535	805
	28.3	**526.4**	**762.2**

The four-week brooding period was done from the first day of November to the last day of November. This time was selected because it is expected that rainfall will be scan and adequate solar radiation will be recorded at the time. The weight of a 10-day old chicks varied from 27g to 30g. The average weight was measured and obtained to be 28.3g. At day 15, the average weight was recorded to be 526.4g. The average weight increased to 762.2g at day 30.

Odo et al. (2016) testing with day old chicks showed that an average live weight of 1024.04 gram was achieved after four weeks with 4% mortality. Ahiaba (2013) recorded that the end of the 21-day brooding operations, an average live body weight of 554.7 grams was attained by the chicks from an initial average body weight of about 29.3 grams. Also, Okonkwo et al. (2007) in their experimental investigation results indicated that at the end of five weeks brooding operation an average live body weight 608g was achieved. Feed conversion ratio vs age of chicks of 586 grams were attained by the chicks from an initial body weight of 29 grams.

CONCLUSION

Energy requirements in developing countries has placed greater burdens on individuals and businesses. Farmers who have depended heavily upon fossil fuels have been especially hard hit. Poultry producers, for example, use significant amounts of natural gas, fuel oil, and propane in heating their facilities. It is incredibly hard and expensive for small holder farmers in Africa to access good quality brooding systems.

Solar Chicks is a solar poultry brooder using non-conventional energy created to dramatically decrease early chick mortality by 70%. This work achieved a good alternative of energy supply to the brooding house using solar energy. Solar energy is a cheap and cleaner source of energy especially in African countries where solar radiation is available. The ambient temperature variation recorded during the experiment was 28°C to 34°C. The average weight of the day-old chicks was measured and obtained to be 28.3g. At day 15 the average weight was recorded to be 526.4g. The average weight increased to 762.2g at day 30.

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ABOUT THE AUTHORS

N.P. Oputa, works with Projects Development Institute (PRODA), Enugu, Nigeria. +2348035976907.

Audu Ibrahim Ali, is a Lecturer at the Department of Mechanical Engineering, Federal Polytechnic, Idah. +2348033322061

E.C. Ugwuoke, is a Master’s degree holder in Energy and Power Technology at the University of Nigeria, Nsukka, and he also works with Projects Development Institute (PRODA), Enugu, Nigeria. His research interest is in renewable energy. He has done research on solar water distillation systems and biogas technologies. emmychyugwuoke@yahoo.com, +2348039308009.

C.P. Ezeigwe, is in the Science Laboratory, Technology Department, Federal Polytechnic Oko, Anambra State, Nigeria.

Muhammed Shaibu, is a Lecturer at Department of Mechanical Engineering, Federal Polytechnic, Idah. +2348162143632.

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