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COMPARATIVE EVALUATION OF SMALL SCALE PASSIVE SOLAR BROODER SYSTEM FOR POULTRY BROODING APPLICATIONS

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ABSTRACT
Comparative evaluation of a small scale passive brooder system for brooding day old chicks was done. The chick brooder system consists of metal aluminum measuring about 1.42m (length) by 0.92m (width) by 0.52m (height). The solar energy collector/heat storage system is a compact unit on top of the brooder house made of metal sheet with dimensions (1.38m x 0.47m x 0.04m). The medium of solar energy storage is water. The brooder system was tested experimentally with day old chicks for about eight weeks under the University of Nigeria, Nsukka weather. The ambient temperature range was 18.6-32.8^{O}C while the brooder temperature range of 24-33^{o}C could be maintained. This shows that the brooder system is a good temperature moderating device. The average weekly global solar irradiance was in the range of 10-605W/m^2 over the period. An average body weight of 3240.57g was attained from an initial body weight of 35g. The recorded mortality rate was 3% while the average feed conversion rate was 1.8.

KEYWORDS: solar poultry brooding, solar irradiance.

INTRODUCTION
The abundance of solar energy and its importance can not be over emphasized. Energy from the sun is intense, clean and abundant especially in tropical regions like Nigeria. The major problem is how to utilize this abundant energy resource effectively and efficiently. So many systems that can covert solar energy to other useful forms have been highlighted in various research journals. Our interest here is to use solar brooder system to brood day old broiler chicks. Solar energy brooding system makes use of energy from the sun which is converted into heat energy for poultry brooding applications. It was noted by Sanjay and Jerry (Sanjay and Jerry, 2006) that much of the energy consumption in poultry rearing (from fossil fuels) occurs during the brooding phase. This is because day old chicks are unable to live for a long time without an additional source of heat other than their own bodies. Hence there is the need to optimize brooding to reduce cost, heat losses while increasing the thermal comfort of the chicks. In this report a small scale passive solar brooder system was used to brood 28 birds from day one to 8 weeks. The performance evaluation of such system is reported and is compared to conventional system of chick brooding.

BROODING
Brooding as defined by (Okonkwo, 1998) is the efficient provision of optimal environmental conditions and nutritional requirement under which day old chicks are raised from day one up to a period of four to six weeks of age. This is the most delicate phase in poultry farming. It refers to early periods of growth when young chicks are unable to maintain their normal body temperature without the aid of artificial supplementary heat (Demeke, 2007). The brooding is necessary because day old chicks need a heated environment to keep them warm since the chicks are yet to develop the heat insulating covers that give them adequate protection against cold weather. Low temperature results to high mortality rate due to salmonella infection, bunching and crowding with the accompanying evil of smothered chicks. Chicks that become overheated will experience problems like pasting, heat stress, dehydration and eventual death (Okonkwo,1998; National Research Council,1966). Hence good performance requires close monitoring and adjustment of brooder temperatures and house ventilation to prevent these conditions from occurring.

The natural brooding method by which the mother hen is used is quite unsatisfactory because it is not suitable for large scale production of birds, exposes the chicks to parasites and attacks by predators like hawk. Artificial brooding makes use of brooder in place of mother hen. It encourages commercial poultry production. Two basic artificial types of brooding systems have been identified from the literature; the localised and the whole space system. In the localised system the heat source is localized and the chicks have access to a cooler unheated area.

The chicks determine their heating requirement by moving from hot to cold areas and vice versa. This is also known as spot brooding. In the whole space brooding, the entire area within the brooder is warmed to the same temperature. The chicks have no choice between cool and warm areas (Smith, 2009). In both systems the heat is provided by various sources like heated oil, coal, wood, water, gas, electricity, etc.

In Nigeria, majority of poultry farmers makes use of kerosene lamps and stoves or a combination of both to supply the heating requirements for brooding day old chicks. This kind of brooding is limited by high cost and most times by the absence of the required fuel. It was noted by (Okonkwo and Akubue, 2007) that it takes a poultry farm of 1000 birds about 40 litres of kerosene to brood day old chicks per day. This translates currently (at the rate of ₦100 per litre) to about ₦4,000 per day and ₦224,000 for 8 weeks. This is quite prohibitive. The technology of fossil fuel brooding also poses environmental problems and health hazards to both plants and animals. Kerosene brooding systems are known to cause fire outbreaks and emission of unwanted gases like carbon dioxide, carbon monoxide etc. which constitutes pollution. Few farmers who have access to grid electricity use the electricity for brooding day old chicks. But with the incessant outages from the national grid electricity network, electricity brooding system in Nigeria using electric power from the national grid is highly ineffective and unreliable. All this problems brings out the beauty of using solar brooding systems as an alternative to raise chicks. Solar brooder systems have the following features:

- They are economically viable.
- They use equipment that is relatively easy to produce and operate.
- They produce cost free energy.
- They improve the quality of the chicks produced.
- They are relatively inexpensive to maintain.
- They rely on construction materials that are available locally.
- There is no emission of gases that pollute the environment.

Solar Brooding System

A solar brooding system has been identified to be either active or passive (Okonkwo, 1998). Active solar brooding systems utilize complex equipment to absorb, release, transfer, or store the energy in the required manner. In some cases active solar brooding systems are supported by auxiliary heating such as electricity, gas etc. to augment the energy collected from the sun through a solar collector. Passive solar energy poultry system depends entirely on solar radiation. There is no auxiliary heating or external support and no complex or mechanical device like fans, dampers or thermostats.

Brooding Temperature

Temperature regulation is one of the critical requirements of a good chick brooding. Maintenance of proper brooding temperature is critical to the success of the brooding operation because it impacts on body weight gain, feed conversion and mortality rate. Poultry men tend not to agree on the temperature range appropriate for the chicks in the first few weeks of life. According to the Okonkwo, the first week brooding temperature should be about 35°C, 31°C-29°C in the second week, 29°C-27°C in the 3rd and should be about 25°C in the 4th week and above (Okonkwo, 1998). Demeke maintained a temperature of 34°C-39°C in the first week of brooding (Demeke, 2007). Ross asserted that the brooder should have an initial temperature of 29°C-31°C after which the temperature should be reduced by an average of 0.2-0.3°C per day (Ross, 2003). What the researchers at Academy of Sciences National Research Council considered as the optimum brooding temperature is 33.9-35°C the first day, which should be reduced to 23.9-26.8°C by the end of the third week and 18.2-21.2°C by the sixth week (National Research council,1966). In this evaluation the brooding temperature range of 29-33°C was maintained in the first week of brooding. The temperature inside the brooder was reduced gradually by opening the vent to about an average of 0.8°C per week. At the eight week the brooder temperature range was maintained at 24-26°C. The mean hourly ambient temperature during the brooding period is as shown in fig 1a. Recommended temperatures for broiler brooding based on heat source is given in Table 1.

Table 1 Recommended temperature for broiler brooding based on heat source

Day	Temperature (°F)		
	Forced air furnace	Pancake brooder	Radiant brooder
0	93	90	88
3	90	88	86
7	87	86	84
14	83	85	82
21	78	80	77

Adapted from (Sanjay and Jerry, 2006)

Relative Humidity

It has been shown in various literatures that chicks kept at appropriate humidity levels are less prone to problems with dehydration and generally make a better and more uniform start. As chicks grow the relative humidity should ideally fall. As the birds increase in weight, relative humidity levels can be controlled using ventilation and heating systems. High humidity may result in wet ceilings, walls, windows and litter while a very dry atmosphere will cause poor feathering. According to researchers at Academy of Sciences National Research Council, a relative humidity of 30-60% may be considered optimal National Research council, 1966). In this evaluation the relative humidity was controlled by adjusting the vent as required.

Brooding space

The cage or brooder height must allow for the birds to stand erect. According to Smith, a minimum clearance of 5 to 6 inches must be maintained over the chick's back (Smith, 2009). The litter floor space for a broiler as adapted from (Okonkwo, 1998) is shown in Table 2. The floor space of the solar brooder used is as described in the next section.

Table 2: Floor space requirement of a broiler

Weeks	1	2	3	4
Floor space (cm/bird)	65-200	120-210	180-300	240-390

Adapted from (Okonkwo, 1998)

MATERIALS AND METHODS

A good solar brooder system should be able to convert solar radiation into useful energy and store the same for utilization when needed. Hence a small sized passive solar brooder constructed at the National Centre for Energy Research and Development, University of Nigeria, Nsukka was used. The small scale passive solar energy chick brooder system consists of metal Aluminum measuring about 1.42m (length) by 0.92m (width) by 0.52m (height). The brooding floor is made of wire mesh which is supported at intervals with steel bar. The wire mesh prevents the chicks from matching on their droppings which could cause them to be affected by coccidiosis disease. Directly below the wire mesh is a poultry manure conveyor made of tarpaulin material. The conveyor facilitates the collection and easy handling of the poultry droppings. The droppings from the chicks were cleared every two days to avoid the formation of ammonia gas that can choke the birds. The solar energy collector/heat storage system is a compact unit on top of the brooder house made of metal sheet with dimensions (1.38m x 0.47m x 0.04m). The medium of solar energy storage is water. The sides of storage system are insulated with wooden materials to reduce and prevent heat loss from the system. There are also vents by the sides of the system which is opened when the temperature is more than required.

Mercury in glass thermometer was used to measure the temperature in the morning, afternoon and late evening. A weighing balance was used to measure the daily weight of 5 randomly selected chicks and the daily average taken. Solar radiation, wind and ambient temperature data was collected from the Centre for Basic Space Science, University of Nigeria, Nsukka. The day old chicks were supplied by Onyinye Chukwu Agro-Vet Ltd, Agro Vet Consultants, 23C Amaeze lane Nsukka and were fed continuously with commercial broiler starter feed for the first four weeks and with broiler finisher for the rest of the period. Good drinking water given to the chicks through out the period while disease preventive measures were taken as prescribed by veterinary personnel. The first week and the third week vaccination were against newcastle disease while the second week vaccination was against gumboro disease. Data on the brooding temperature, body weight gain, feeding rate, mortality rate and maturity rate were collected from the 28 birds used. A picture of the solar brooder and of the birds insider the brooder house at one week, two weeks and at eight weeks respectively are shown in Fig 1.

Figure 1 (a) picture of the brooder house (b) the birds at one week (c) birds at 6 weeks. (d) the birds at 8weeks

RESULTS AND DISCUSSION.

The evaluation covered an eighth week period from 30th September to 24th November 2009. Table 3 summarizes the solar radiation data showing weekly hourly (9a.m-6.p.m.) solar radiation as obtained from CBSS, while Table 4 shows the maximum and minimum ambient and brooder temperatures. While the brooder temperature ranged between 29-33°C, the ambient condition was between 19.8 – 32.8°C in the first week of brooding. The mean hourly ambient temperature and solar radiation for each week is shown in Fig 2a and 2b respectively. The brooder temperature remained reasonably stable rising slowly during the day to around 33°C and falling of gradually during the morning hours. The overall rate of change in the brooder temperature against outdoor temperature suggests the moderating effect of the brooder.

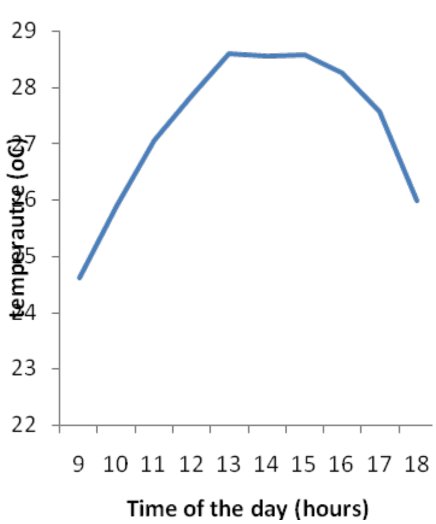
The experimental evaluation indicated that at the end of the eight weeks brooding operation, an average body weight of 3240.57g were attained from the initial average body weight of 35g. The feed consumption per chick and the average weight gain for each week is as shown in Figure 3. Figure 4 shows the feed conversion ratio for each week per chick. The results compared more than favourably well to what other authors in this area has done (Okonkwo and Akubue, 2007; Ross, 2003. The performance of a broiler based on other chick parameters as adapted from National Centre for Energy Research and Development, University of Nigeria, Nsukka using kerosene, electricity and solar brooding system is shown in Table 5. The mortality rate was 3% while that of kerosene and electric brooding systems from the literature is 7% and 10 % respectively.

Table 3: Weekly mean hourly solar radiation (W/m²)

	9am	10am	11am	12noon	1pm	2pm	3pm	4pm	5pm	6pm
1st week	221	333	461	425	568	385	319	270	119	23
2nd week	199	328	328	289	369	341	187	110	84	11
3rd week	259	351	287	366	421	383	387	252	103	18
4th week	246	338	346	326	350	319	325	198	106	10
5th week	239	343	326	345	349	380	347	219	90	10
6th week	235	352	409	360	352	378	243	221	111	10
7th week	264	323	423	307	376	487	440	258	104	11
8th week	371	308	569	329	347	605	488	309	112	13

Table 4 Maximum ambient and brooder temperature (°C)

Weeks	Ambient temperature		Brooder temperature	
	Maximum	Minimum	Maximum	Minimum
1st	32.84	19.84	33.0	29.0
2nd	30.47	19.85	32.5	28.5
3rd	31.11	20.02	31.3	28.0
4th	31.84	20.05	30.2	26.6
5th	32.59	20.41	29.4	25.2
6th	31.58	22.21	28.5	24.5
7th	3.972	21.08	27.3	24.2
8th	32.52	18.6	26.2	24.2



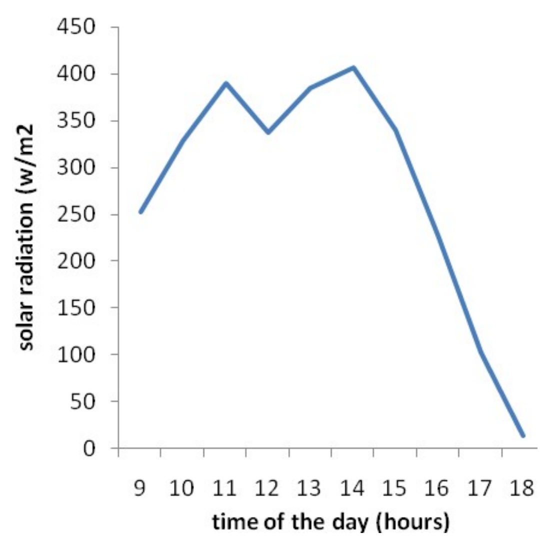


Fig 2a: Hourly mean ambient temperature (from 9.00a.m- 6pm) (b): Mean hourly solar radiation (from 9.00am -6.00p.m)

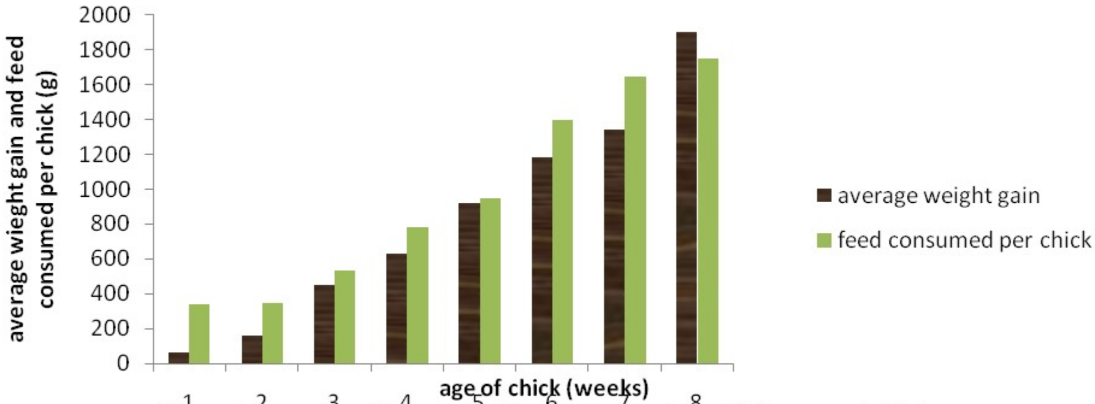


fig ure 3 Average weight gain and feed consumed per chick vs age of chick

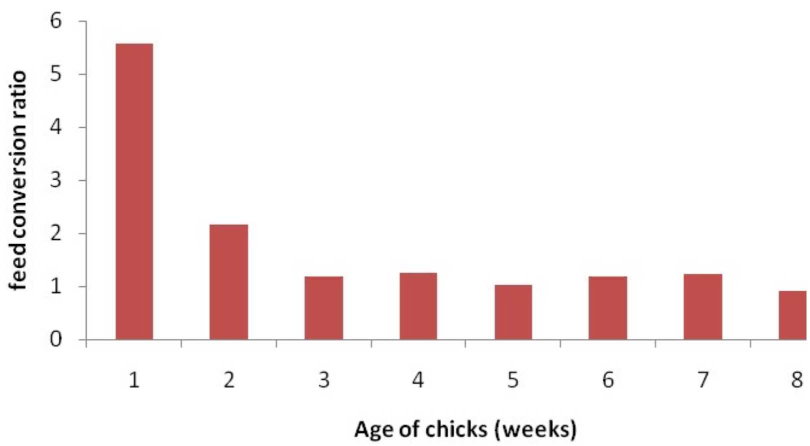


fig ure 4 Feed conversion ratio vs age of chicks

Table 5: Performance of broiler chicks under three brooding systems

Chick parameters	Kerosene	Grid Electricity	Solar Energy
Initial body weight(g)	49.84	49.91	49.91
Final weight(g)	452.16	400.01	562.74
Feed intake	39.30	37.20	38.37
Weight gain (g/day)	14.39	12.50	12.31
Feed conversion ratio	2.73	2.89	1.9
Mortality rate (%)	7	10	3

Adapted from National Centre for Energy Research and Development, University of Nigeria, Nsukka

CONCLUSION

The evaluation of the small scale solar brooder system has been presented. The results shows that the brooding temperature range of 24-33^{o}C could be maintained in the brooder with an ambient temperature of 19-32^{o}C. Also the evaluation showed a mortality rate of 3% and a weight gain percent of more than 9000. This indicates an overall efficiency of about 97%. The above results shows that the small scale passive solar brooder system could sustain day old chicks hence is a good heat storage and temperature moderating device for poultry brooding operations.

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