Journal of Engineering Science *Vol. XXVII, no. 4 (2020), pp. 65 - 75*
Fascicle *Industrial Engineering* *ISSN 2587-3474*
Topic *Applied Engineering Sciences and Management* *eISSN 2587-3482*

DOI: 10.5281/zenodo.4288267
CZU 621.3:620.9:636.5(662.6)

ENERGY USE PATTERN OF SELECTED COMMERCIAL POULTRY FARMS IN OGUN STATE, NIGERIA

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Received: 10. 14. 2020
Accepted: 11. 25. 2020

Abstract. Energy represents an important component of agriculture and essential to the sustainable production of poultry meat and egg. Despite several efforts at ensuring self-sufficiency in the local production of poultry products through the provision of fast-growing disease-resistant breeds, high energy feeds and improved health care amenities, little efforts have been made in the estimation of critical energy needs of the poultry industry in Nigeria. This study investigated the daily energy utilization pattern of 10 selected commercial poultries farms in a major agricultural state in the country, Ogun State Nigeria. The study was carried out using a structured questionnaire, oral interview, and site observation. The predominant sources of energy alongside the mean daily energy were; electricity (37053 MJ, 36%), Diesel (2868 MJ, 30%), petrol (606.30 MJ, 29%), human labour (76.23 MJ, 4%) and other sources of energy (13.16 MJ, 1%). There was a weak relationship between the total energy consumed per day and the poultry capacity (R^2 = 0.3772). The Anova of Energy Use, feed consumption, bird weight and egg production showed no significant difference across the farms (P=0.301886, α=0.05). Feeding, water pumping, ventilation and lighting (heating) were the major energy consumers on the farm.

Keywords: *electrical energy, energy content, poultry feeds, liquid energy, manual energy.*

Introduction

Generally, agriculture and allied industries such as the production of machinery, fertilizers, feed concentrate for livestock, agrochemicals, water, and agro-processing, is an energy-intensive activity [1] which is faced with the task of meeting the increasing demand for high-quality food, and fibre in addition to being cost-effective and sustainable [2]. Thus, energy remains an indispensable input of any production venture and it therefore represents a key index of agricultural production. Energy cost is a significant component of the operational expenses incurred running a poultry production facility [3].For instance, energy costs of electricity and fossil fuel, constitute more than 50% of cash expenses of

growers producing poultry facilities [4]. Due to the economic implications and operational characteristics of poultry production, farmers have a limited set of production variables and profitability is often enhanced through reducing operating costs [3] and optimization of the controllable variables. Following government's policy on restriction of poultry importation into Nigeria, there has been an increase in the number of poultry farms in the country [5]. However, despite the policy, poultry production has not been able to keep pace with the surging demand for poultry products for domestic consumption and industrial end use respectively [6]. This could be as a result of the farmers limitation in terms of appropriate technology adoption and energy mix to power large scale poultry production efforts as identified by Jekayinfa [5, 7], FAO [8, 9].

Energy use in poultry production is an area of interest to so many researchers and different studies have been carried out to evaluate, characterize and improve the efficiency of the poultry industry at the small, medium and commercial levels respectively. Jekayinfa [7] investigated the energy utilization pattern of selected typical mechanized farms in Oyo, Ogun and Osun States of Nigeria where he discovered that the average energy consumption per year in poultry production was 90.74 GJ with fossil fuel and electricity making up 58% and 42% respectively of the total energy used. Also, Jekayinfa [5] carried out an energy audit of poultry processing plants in southwestern Nigeria where he discovered that scalding and defeathering processes were the most energy-intensive unit operations in all the unit operations investigated as they averagely accounted for about 44% of the total energy consumption in the processing plants while eviscerating, slaughtering, washing & chilling and packing consumed 17.5% 17% 16% and 6% respectively. Liang *et al.* [3] discovered that the energy use for ventilation and lighting comprised about 87% of the total energy usage in both enclosed and open curtain poultry systems in Northwest Arkansa over a 17 year period. Firouzi [10] also carried out an energy audit for broiler production in Northern Iran over two production seasons where he observed labour, fossil fuel and electricity as major energy sources during his study. Similar observations were recorded by Amini *et al.* [11], Kalhor *et al.* [12], Amid *et al.* [13], Kilic [14], Heidari *et al.* [15], Yamini *et al.* [16] and Najafi *et al.*[17].

Despite targeted measures to revive the economy and encourage the local poultry farmers by the federal government to increase poultry production in Nigeria; these efforts are yet to produce the desired expectations. Hence, the productivity of the poultry industry (poultry meats, eggs etc.) is still much behind in terms of availability and affordability of poultry products compared to other livestock. The reduction in livestock productivity experienced in recent times may not be unconnected to the pattern of energy use in the production process among other factors. The energy use is central in the production process and therefore must be properly recognized and applied appropriately at different levels of the production process. It is against this background that the understanding of energy use patterns will contribute to the knowledge needed to improve poultry production capacity and therefore the main focus of this study.

Energy use pattern generally varies in different poultries in Ogun state which affects the rate of growth of poultry production. Additionally, there is very little information on the state of energy utilization of many poultry farms in Ogun State which could serve as a tool for policymakers and researchers in making the right energy policies as well as improving the efficiency of existing energy utilization pattern respectively. This study, therefore, examines the different energy use patterns of selected poultry production farms in Ogun

state with the view of explaining the effect of the energy use on the production process. Specifically, this study identifies the major energy sources in use, determine consumption levels of each energy source as well as to determine an energy consumption index for each selected poultry farm.

Materials and Methods

Sampling Method and Sample Characteristics

Ten commercial scale poultry farms were randomly selected across the four geopolitical areas of Ogun State Nigeria (7° 0′ 0″ N, 3° 35′ 0″ E) which include Remo, Ijebu, Egba and Yewa axes of the State. The structural composition of poultry housing is majorly the combination of steel and wire frame housing units on a concrete foundation. The major units of each poultry were identified and information about the daily operations retrieved from each of the production units.

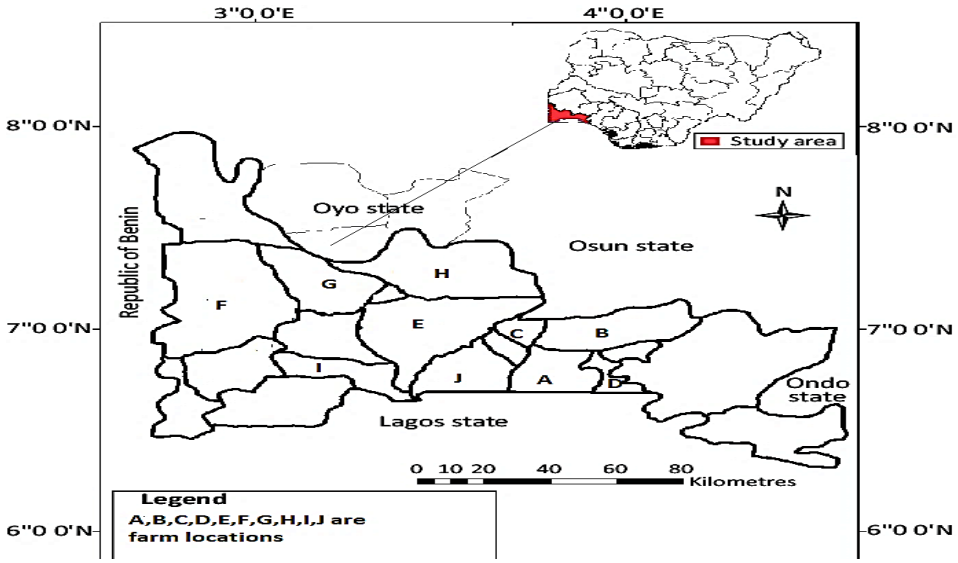

Figure 1. Map of the Study Areas.

Data Collection

Data was collected from each poultry through the following methods:

I. ON-site study of all unit operations at each poultry.
II. A structured questionnaire was administered on patterns of energy use by the above-mentioned poultry for one day and information about their routine for the month.
III. Oral interviews

Energy

The energy inputs and the energy use on the poultry farm were calculated based on the sources and types of energy consumed on the farm for the working hour per day in line with Abubakar *et al.* [18], Adetifa and Oyewole [19] and Babalola *et al.* [20].

Energy Input

The source of power will be investigated to determine power consumption. And in estimating the energy available and consumed, the following empirical formulas reported by Abubakar *et al.* [18]. The inputs of poultry production systems include machinery, fossil

fuels, electricity, labour, feed, while the output includes poultry birds, eggs and poultry wastes or litter [10].

Evaluation of Manual Energy Input: Manual energy input was estimated from Eq. (1) and Eq. (2) for male and female workers respectively;

$$E_{Mm} = 0.75T_a \quad (1)$$

$$E_{Mf} = 0.68T_a \quad (2)$$

Where; E_{Mm} is the male manual energy input (MJ), E_{Mf} is the energy input, from a female adult (MJ), 0.75 is the energy factor of an average adult male (MJh^{-1}), 0.68 is the energy factor of an average adult female (MJh^{-1}), T_a is the useful time spent by a worker per unit operation (h).

Evaluation of Liquid Fuel Energy: The Liquid fuel energy was estimated using Eq. (3) and Eq. (4) for diesel and petrol, respectively.

$$E_{FLD} = 47.8D \quad (3)$$

$$E_{FLP} = 42.3P \quad (4)$$

Where; EFLD is the liquid fuel energy input for diesel, (MJ), 47.8 is the unit energy value of diesel, (MJL^{-1}), D is the Amount of diesel consumed per unit operation, (L), 42.3 is the unit energy value of petrol, (MJL^{-1}), P is the amount of petrol consumed per unit operation, (L).

Electrical Energy: Data on electricity consumption (kWh) was estimated from the bills collected over the month under review [18]. These values were converted into common energy unit (MJ) by using appropriate coefficient (Eq. 5)

$$E_E = 11.99 * kWh, MJ \quad (5)$$

Hence for each of the unit operation, the total energy used would become:

$$\text{Total Energy is, } E_T = E_M + E_{FL} + E_E \quad (6)$$

Energy Use Ratio

The total energy content (energy output) of finished product was first estimated from the energy content of the finished products (E_{FP}) of meat, egg, machinery output, birds. This was evaluated from Eq. (7).

$$E_{FP} = M_{FP} \times E_{CP} \quad (7)$$

Where; E_{FP} is the total energy content of finished product (MJ), M_{FP} is the mass of finished product (kg), E_{CP} is the energy content of a unit mass of product ($MJkg^{-1}$).

The energy use ratio was evaluated from Eq. (8):

$$E_{UR} = E_{FP} / E_T \quad (8)$$

Where; E_{UR} is the energy use ratio, E_{FP} is the total energy content of finished product (MJ), E_T is the total energy input for operation (MJ).

Results and Discussions

The predominant unit of importance in all the sites visited was the breeding units where poultry birds are kept for their egg production or till eventual maturity for sales as in the case of the broilers. Data obtained from the field shows that 50% of the poultry farms rear only layers while the other 50% rears both layers and broilers.

Poultry Characteristics

Figure 2 shows the bird population in each of the poultry farms covered by this study. The farm with the highest bird population has 100,000 birds consisting of layers birds only. While the farm with the least birds has 2000 layer birds population. 50% of the farms are into egg production only while the other 50% are into the production of eggs and meat.

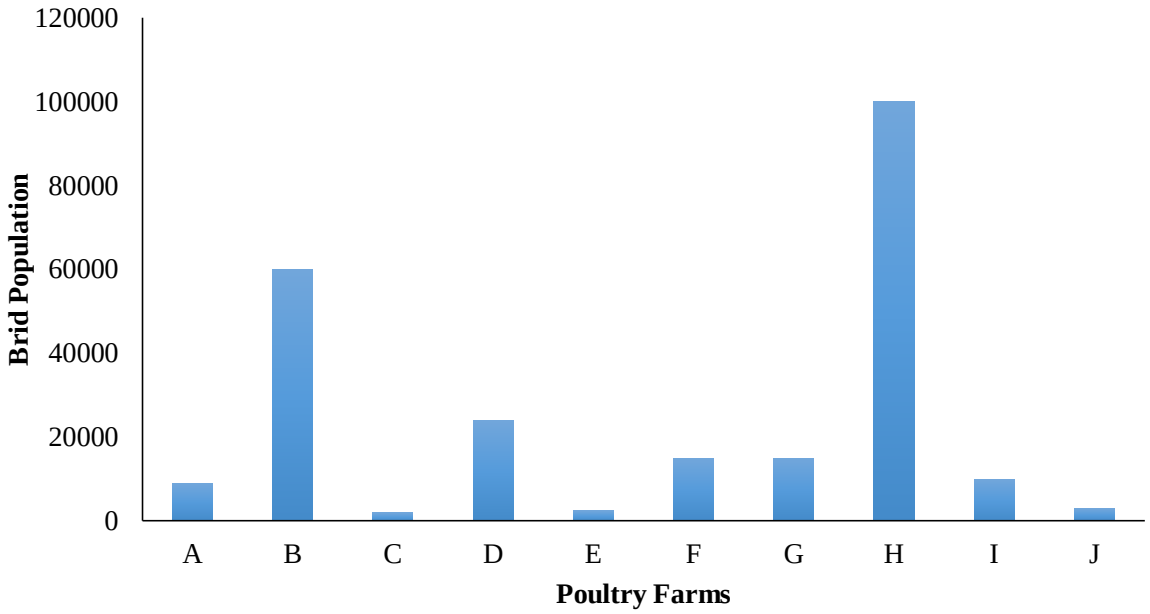

Figure 2. Bird population across various farms.

The unit weight (kg) of birds, daily feed and water consumption levels of the selected farms are highlighted in table 1. The weight of a bird in this context refers to the average weight of a bird on each poultry farm visited. From table 1, the result revealed that the majority of the birds weight falls in the range of 1.1-1.5 kg which means that 66.67% of poultry has a regular weight of 1.3 kg. 11.11% are in the range of 1.91-2.3 kg range and the rest falling into the 1.51- 1.9 kg category occupying 22.22% of the total bird population.

The weight of the feeds per bag is 25 kg which consisted of required nutrient which helps birds grow properly. The mode of feeding can be either automated or manually and there feeding pattern also determines the number of bags they consume per day. Table 1 also shows their feeding pattern and consumption percentage of the considered farms. Results show that those that feed twice daily has the highest percentage (50%) which ranges from 1-500 kg of bags per day with a little population of birds, range of 501- 1000 kg which is (20%) feeds thrice daily with little population, range 1001- 1500 kg which is (20%) feeds twice daily with a large population and above 1500 kg which is (10%) feeds thrice daily.

Table 1 also reveals the various sources of water available to the farms. The daily consumption of water ranged from 1000 litres to 50,000 litres, while the source of water were a combination of well and drilled boreholes. The water from the wells went through a set of treatment tanks before being fed to the poultry birds, while routine tank washing was usually done to the borehole sourced water.

Table 1 shows that 42.9% of the farms discharge their waste as manure, 28.6% discharges their waste as composting, 21.4% flushes it off and 7.1% burns it. None of the farms visited had a biowaste energy conversion plant. Table 1 also shows the different types of materials stored in the poultry farms. It was observed that 31% stored feeds only, 30% stored both feeds and eggs, 30% stored eggs only, 6% stored meat using cold rooms while 3% has storage for feeds, eggs, and meats on their farms.

Table 1

Poultry Characteristics

	Categories	Percentage
Unit weight (kg)	1.1-1.5	66.67%
	1.51-1.9	22.22%
	1.91-2.3	11.11%
Daily feed consumption (kg)	1-500	50%
	501-1000	20%
	1001-1500	20%
	Above 1500	10%
Daily water consumption (Litres)	1-10000	30%
	1001-2000	30%
	2001-3000	10%
	Above 3000	30%
Water source	Borehole	62%
	Well	23%
	Borehole and well	15%
Waste management technique	Flushing	20%
	Manure	40%
	Burning	5%
	Composting	25%
Products stored	Meat only	6%
	Eggs only	30%
	Feeds only	31%
	Feeds and eggs	30%
	Feeds, meats and eggs	3%

Poultry Farm Workers

The manual labour chart is shown in figure 3. It was observed that the number of workers varied according to the capacity holding of the farm. The result from table 2 shows that females dominated the farms with the working hours of 8 and 9 hours daily while working hour 10 is dominated by males. It was observed that 50% of the farms visited works for 9 hours daily, 30% works for 8 hours daily and 20% works for 10 hours daily.

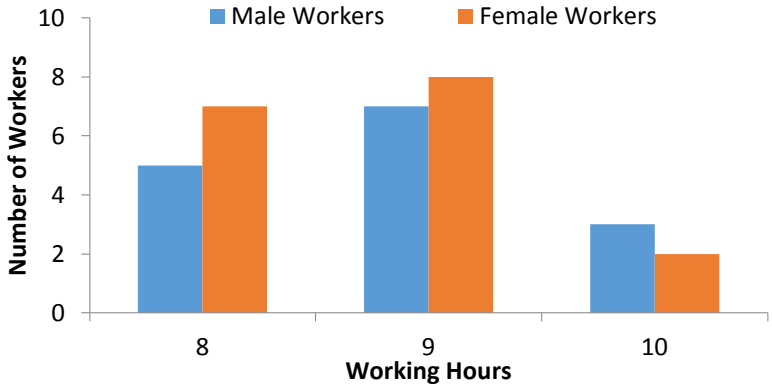

Figure 3. Number of workers with the corresponding working hours.

Manual Energy Analysis

Table 2 shows the manual energy consumed at the poultry using equations 1 and 2. The result shows that the higher the capacity the higher the energy consumed. It was observed that energy from female workers is more which is because female workers dominate more of the poultry farms.

Table 2

Descriptive statistics on manual energy (n=10)

Statistics	Energy From Male Workers (MJ)	Energy from Female Workers (MJ)	Total Manual Energy (MJ)
Mean	37.13	39.10	76.23
Standard Deviation	39.24	49.56	61.62
Range	135.00	171.36	196.11
Minimum	6.75	0.00	22.50
Maximum	141.75	171.36	218.61

Electricity from National Grid

It was observed that 50% of the farms visited depended on electricity as one of the major sources of energy to drive their operations. Critical among the major needs for electricity include: operating electric motors, water pumps, lighting, ventilation, and cold storage respectively which agrees with the findings of Liang *et al.* [3] and Firouzi [10]. Table 3 shows the descriptive statistics of the electrical energy used across the sites visited. The corresponding costs of electricity were obtained from the monthly electricity bills of the various farms respectively.

Table 3

Descriptive statistics of energy from national grid (n=10)

Statistics	Energy Consumption (MJ)
Mean	37053.06
Standard Deviation	71361.15
Range	191857.14
Minimum	2428.57
Maximum	194285.71

The maximum electricity cost of ₦400,000 at was observed at farm H (100,000 bird population) which translates to energy value of 194285.71MJ (1 Kwh of electricity = ₦30.86

[21]) the minimum cost of ₦5000 (2428.57 MJ) was recorded at farm C with 2000 birds and mean value is ₦76285.71(37053.06 MJ) across the farms. The major electricity needs were water pumping, feed mixing, lighting and ventilation which are in line with the findings of Liang *et al.* [3], Jekayinfa [6] and Firouzi [10].

Liquid Fuel Energy Consumption

The energy expended in the operation of petrol engine/generator in the various poultry had the highest values of energy use accounting for more than 90% of the total energy used. Table 4 shows that farm with a bird population of 24000 uses petrol, diesel and as liquid fuel which makes it the highest energy consumed per day from liquid fuel.

Table 4

Descriptive statistics on daily liquid fuel energy consumed (n=10)

Statistics	Petrol Energy (MJ)	Diesel Energy (MJ)	Kerosene Energy (MJ)
Mean	606.30	2868	13.16
Standard Deviation	582.54	2027.98	30.76
Range	1903.5	2868	94
Minimum	211.5	1434	0
Maximum	2115	4302	94

It was observed from the result presented in table 4 that the liquid fuel consumed the most is energy from diesel and the least consumed is energy from kerosene.

It is clear from the figures that much petrol fuel energy was used by the poultry per day under review, a scenario similar to the findings of Jekayinfa [6]. The cost of petrol was ₦145 per litre while the cost of a litre of diesel averaged ₦215 during the period of the study.

Solar Energy Utilization

This study gathered that 30% of the farms visited had solar power as one of the power sources on their farms.

The capacities of the solar installation ranged from 2 kW to 10 kW at Farms A, B, and C which were used for lighting and ventilation of the farm environments and as a backup in case the main power sources experienced challenges.

Total Energy Consumed

The total energy consumed is shown in Table 5 which shows a mean energy consumption of 54608.66 MJ.

The regression analysis showed that the total energy consumption correlated with the capacity of the poultry farms (figure 4). Table 5 also presents the energy use pattern in the poultry farms studied.

The energy use ratio shows a maximum energy advantage of 0.14 MJ/bird for farms C and J while the minimum value of 0.03 is observed in farm D. Only the work of Firouzi [3] comes close with an energy use ratio of 0.28 in one of the study areas in his study.

This study reveals that the energy use is very low as a result of high energy consumption. There is, therefore, an urgent need to reduce the amount of energy consumed.

Table 5

Descriptive statistics on total energy consumed and energy use ratio (n=10)

Statistics	Total energy consumed (MJ)	Energy use ratio
Mean	54608.655	0.083
Standard Deviation	126102.704	0.047
Range	401130.250	0.114
Minimum	445.500	0.032
Maximum	401575.750	0.146

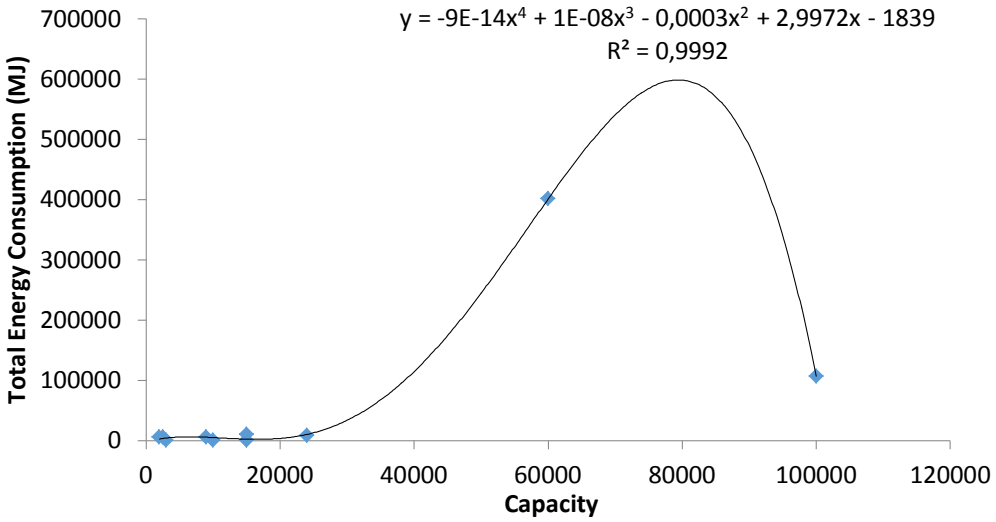

Figure 4. Total energy consumed versus poultry capacity.

The energy mix of the study areas is shown in figure 5. Overall, electricity contributed most significant energy (36%) to the operations of the farm followed closely by diesel (30%) which compares favourably with 33.34% reported by Firouzi [3] petrol (29%) and human labour (4%) while others (solar, kerosene, and charcoal) make up the remaining 1% respectively.

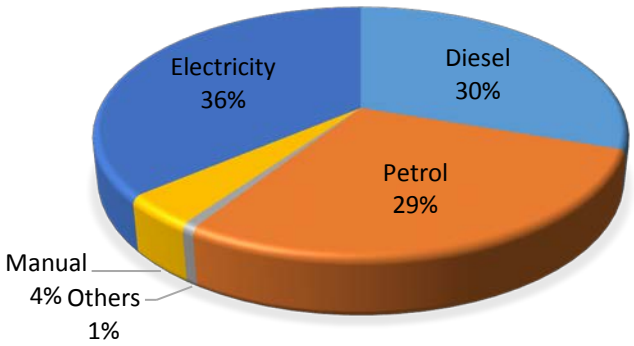

Figure 5. Energy mix of the study areas.

Conclusion

A Study on the energy use pattern of 10 selected commercial farms was carried out with the following findings: all of the farms had more than one source of energy with diesel and petrol engine powered operations making up the bulk of the energy utilization. The role of manual labour, energy consumption, and bird weight and egg production across

each farm showed no significant difference. The farm with the highest bird population had 100,000 birds while the least populated farm had 2000 birds. The daily energy utilization revealed that feeding, water pumping, ventilation, and lighting (heating) were the major energy consumers on the farm. The maximum energy derivable was from electricity was 6476 MJ/day while diesel and petrol gave 4302 MJ and 2115 MJ of daily energy respectively. The energy use ratio varied from 0.04 to 0.14 across the farms. This study can serve as a guide on the daily energy utilization requirement for new poultry farmers and industry stakeholders who are looking for literature to guide policies and legislations on poultry production in Ogun State and Nigeria.

Recommendation

Since all the farms visited produced wastes, further studies can be carried out to characterize the poultry wastes and their suitability for biogas and electricity generation within the farm premises as none of the farms had the facilities for the conversion. Similarly, Farms F, I and J which are located in Ijebu Ode, Abeokuta, and Osiele had no electricity on their farms as their vicinity had no connection to the national grid. The government should help improve standards or establish law guiding the standard of energy to use at the identified capacity holding of farms. The equipment documentation and maintenance schedules were not properly kept in most of the farms visited making the manufacture, and repair energy estimation impossible; hence, these and other related documents should be kept intact for further energy utilization analysis.

Acknowledgments. The authors are grateful to the management of Rasable Ventures, Animalhood Global Resources, Eleshin Livestock farms, Daddy Abbey farms, Ayanleye farms, DLM farms, Jaiyesimi farms, Addak farms, Eltees farms, and Oyenuga farms for their support throughout this study period.

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