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Comparative Analysis of Egg Production in Deep Litter and Battery Cage Technologies in Akwa Ibom State, Nigeria

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Abstract
The study analysed and compared table eggs production in battery cage and deep litter systems in Akwa Ibom State. Primary and secondary data were used for this study. Primary data was obtained through the administration of a structured questionnaire to 100 respondents. The specific objectives were to determine and compare the socio-economic characteristics of battery cage and deep litter farmers, obtain and compare the number of eggs produced in both systems, estimate and compare gross margin and profitability in both systems and identify the factors that determine egg output in the study area. The data were analysed using descriptive statistics, budgetary techniques, and the ordinary least squares multiple regression models. The result showed that the average stock size in the study area in battery cage and deep litter systems were 2176 and 2091 respectively. For one production cycle of about 18 months, the total variable cost (TVC) was ₦33, 458, 889.00, the gross margin was N7,275268.00 and the gross margin per bird was N3,387.00 for the battery cage system. Also, the TVC and gross margin were ₦33, 398, 709.00, and N6,198185.00 respectively and the gross margin per bird was N2,964.00 for the deep litter system. The Total costs of production were ₦34, 287, 884.00 and ₦34, 076, 858.00 for battery cage and deep litter technologies respectively. The profits were N6,446,274.00 and N5,186,698.00 for the battery cage and deep litter systems respectively. The rate of return on investment was found to be 17.49% and 13.93% for battery cage and deep litter technologies respectively. The regression result for poultry production in deep litter and battery cage technologies showed that education ($\alpha_{0.01}$), age of birds ($\alpha_{0.1}$), Experience ($\alpha_{0.1}$), and stock size ($\alpha_{0.01}$) were significant variables affecting the number eggs produced. The study, therefore, concludes that egg production under battery cage was more profitable in the study area than deep litter technology. Due to the huge cost outlay associated with layer production, it is recommended that grants and loans should be provided to poultry egg farmers at low-interest rates, the farmers should be trained and encouraged to produce their feed to offset the high cost of feed incurred in the production.

Keywords: Deep litter, battery cage, egg production, gross margin

Introduction

Nigeria has a population of 190 million people making it the most populous nation in Africa and it is anticipated to reach about 400 million in 2050 indicating that the demand for livestock products will rise exponentially. It was also projected that meat consumption will grow by about 253% (FAO, 2019). One of the challenges facing developing countries is their inability to adequately feed their ever-increasing population with the right proportion of calories and protein (Aladejebi, Okojie, and Afolami, 2014). FAO (2019) reported that 53 per cent of the population of Nigeria lives under the poverty line with the majority of this population living in rural areas. This has caused an average person in Nigeria, Akwa Ibom State inclusive to be unable to afford nutritious meal. The egg comes in handy to help in addressing this challenge since it is a very cheap and affordable animal protein source, especially for low-income households in Akwa Ibom State. According to Ayinde, Ibrahim, and Arowolo, (2012), poultry industry is one of the major sources of animal protein in Nigeria. Udo, Akpan, and Okon (2017) posited that poultry can be relied upon in solving the deficit in protein supply in the short run. This sub sector has also provided employment directly or indirectly to a greater proportion of Nigerians (Mohammed, Malumfashi and Obekpa, 2007). The business of poultry farming comprises chickens, turkeys, geese, ducks, quail, and guinea fowls (Ekaette, Ohen, and Idiong, 2018). Poultry production is the highest livestock category contributing about 180,000 million, consisting mainly of chickens, ducks, and turkeys (FAO, 2019).

Protein contributes to body building and the repair of

worn-out tissues. It also provides necessary nutrients to pregnant and lactating women as well as young children (Aladejebi *et al.,* 2014). Also, by providing meat and eggs, the poultry industry also contributes to food security and nutrition (FAO, 2019). Egg production is an important source of high-quality protein for the global population. Eating one egg per day is a good way of including protein, fat, vitamins, and minerals in the human diet (Madubuike, 2012). Egg is contributing to the realization of the sustainable development goal (SDG 2) that seeks to end all forms of malnutrition, by 2025 - the internationally agreed targets on stunting and wasting in children under 5 years.

The level of production in Nigeria is below the demand. In the past, the Nigerian government in an attempt to alleviate this problem of protein deficiency, resorted to mass importation of protein products like poultry meat. The current administration is emphasizing self-sustainability in poultry production and a ban had been placed on the importation of all poultry products. The challenge caused by the ban, is that of harmonizing or balancing the shortages in supply caused by the ban on importation of frozen chicken and the only way out is by increasing poultry production. (Udo *et al*., 2017). One of the causes of insufficient production to meet local demand is the type and level of technology especially in the livestock subsector.

Successful poultry business requires two main factors which are feeding and housing Kogoor *et al.* (2021). The choice of housing system plays a pivotal role in achieving efficient egg production while ensuring animal welfare and economic viability. Among the various housing and technology available, the deep litter and battery cage technologies have been widely implemented in commercial egg production in Akwa Ibom State. Each system has its advantages and challenges, necessitating a thorough analysis of their economic implications.The choice between these systems involves considering multiple factors, including the initial investment, operating costs, labor requirements, feed efficiency, egg quality, and overall profitability. A comprehensive cost analysis is necessary to understand the financial implications associated with each system and guide decision-making for poultry farmers and industry stakeholders.

The deep litter system, also known as floor housing, offers hens a more natural environment, allowing them to move freely, exhibit natural behaviors, and have access to open spaces. This system employs litter, such as straw or wood shavings, to provide hens with a comfortable and hygienic flooring. On the other hand battery cage is a type of intensive poultry housing system in which chickens are kept in compartment units. It involves confining hens within small wire cages, typically arranged in tiers, which restricts their movement but facilitates easier management and monitoring. The battery cage technology has advantages of reducing aggressiveness and cannibalism behavior associated with hens (Meseret, 2016). However, it constitutes some challenges especially to the welfare of birds, like restriction of movement prevention of natural behaviors and production of barren birds (Meseret, 2016). The European Union Council Directive 1999/74/EC banned the use of conventional battery cages in the European Union EC due to this welfare issues (European Union Council Directive, 2012). However, Duncan (2001) analysed the advantages and disadvantages of battery cage systems. He reported that this system has the merit of low incidence of diseases, low incidence of social frictions, and the absence of problems resulting from litter and the demerits as lack of both physical and psychological space for laying hens, lack of space for daily activities and nesting and dust bathing opportunities, and a higher incidence of foot lesions.

Despite these advantages and disadvantages of both systems an investor in the business will be interested on the cost and revenue structures associated with both systems. Also the current spate of price fluctuations and rate of inflation in the country does not allow agricultural entrepreneurs to rely on records of production costs and returns to plan and take decisions on future production. Also, there is little or no literature on comparative study of economic implications of egg production in deep litter and battery cage systems in Akwa Ibom State. It is on this premise that this study analyzed and compared the current production costs and returns of deep litter and battery cage systems of egg production in Akwa Ibom State. Specifically, the study determined and compared the socio-economic characteristics of poultry egg farmers in deep litter and battery cage technologies in the study area, obtained and compared the quantity of eggs produced in deep litter and battery cage technologies, determined and compared the profitability in battery cage and deep litter systems of poultry egg production in the study area and determined the factors that affect egg output in both systems in the study area.

Research Methodology

The Study Area

The study was conducted in Akwa lbom State, Nigeria. The State lies on the coastal plain of Southern Nigeria with a land mass of 8,412 sq. km. There are 31 Local Government Areas which are divided into three senatorial districts with Uyo as the State capital. The state is located between the latitude 430° and 530 ° n and longitude 730 and 8 15 E. Akwa Ibom State shares borders with River State in the West, Abia and Imo State in the North, Cross River State in the East and Atlantic. The total population of the state was 3,920,208 persons in 2006 (NPC 2006) with the national population growth rate of 2016 Akwa Ibom State population is about 9,565,307 persons. The State is known for the production of crops such as cassava, yam, cocoyam, maize, rice, cowpea and melon while cash crops - oil palm, coconut, rubber, cocoa, raffia palm, plantain, and banana, It also produces livestock such as sheep, goats, rabbits, and poultry. The state has a comparative advantage in poultry production because of its climate that favours the production of different livestock

including poultry. However, the two major systems in commercial production in the states are the battery cage and deep litter and battery cage technologies.

Sampling Size and Sampling Techniques

Three Local Government areas were purposively selected for this study. These Local Government Areas were selected because they have a higher population of poultry egg farmers. The selected Local Government Areas included: Uyo, Ikot Ekpene, and Abak. With the assistance of (AKADEP) extension agents from those Local Governments, lists of major poultry farmers were obtained. From the list, fifty per cent (50%) of poultry egg farmers for each of deep litter, battery cage and those practicing both on their farms were selected from each of the Local Government Areas as presented in Table 1. Based on the result (Table 1) a total of 100 poultry egg farmers under different technologies were randomly selected from the three Local Government Areas from the list.

Analytical Technique

The analytical technique that were applied for the study are descriptive statistics, analysis of cost and returns and multiple regression analysis based on ordinary least squares. Descriptive statistics was applied to the socio-economic characteristics of egg farmers and the quantity of eggs produced in each technology. Profitability in deep litter and battery cage systems was analyzed using the analysis of costs and returns and the determinants of egg production were analyzed with multiple regression analysis.

The socio-economic characteristics of laying bird farmers were analyzed using descriptive statistics such as frequency tables, means and percentage distributions. An example of the formula that was used in analyzing this objective is the mean which is stated thus:

$$\text{Mean} = \overline{X} = \sum_{1=1}^{n} \frac{fx}{n} \ldots\ldots\ldots (1)$$

To obtain and compare the number of eggs in deep litter and battery cage technologies: This objective was analyzed using descriptive statistics such as frequency tables, means and percentage distributions. To determine the profitability in deep litter and battery cage technologies: Analysis of costs and returns of both enterprises were estimated thus:

$$\pi = TR - TC \quad \ldots\ldots\ldots (2)$$

Where: π = Profit, TR = Total revenue (₦), TC = Total cost

$$TC = TFC + TVC \quad \ldots\ldots\ldots (3)$$

TR = QP, Q = Quantity, P = Unit price, TVC = Total Variable Cost (₦), TFC = Total Fixed Cost

Profitability was determined by financial ratios as follows:

The Rate of Return on Investment (RROI) and Rate of Return on Fixed Cost (RRFC) were used to determine and compared the measure of financial outcomes of the poultry egg farmers that used battery cage or deep litter systems in the study area. They were calculated as follows:

$$\text{RROI} = \frac{\text{Profit}}{\text{Total Cost}} \text{X } 100 \ldots\ldots\ldots (4)$$

$$\text{RRFC} = \frac{\text{Gross margin}}{\text{Total fixed cost}} \text{X } 100 \ldots\ldots\ldots (5)$$

The straight- line depreciation method as shown was used to calculate the depreciation cost of the equipment, (fixed assets):

$$\text{Annual depreciation} = \frac{CP - SV}{n} \ldots\ldots\ldots (6)$$

Where; CP = Cost price (₦), SV = Salvage value (₦), n = Useful life span of the asset (Years).

The determinants of eggs produced: This was accomplished using the OLS multiple regression analysis.

The implicit form of the model for objective four is specified as follows:

$$Q = f\ (X_1, \ldots, X_n + \mu) \quad \ldots\ldots\ldots (7)$$

Where:

Q =Number of crates of eggs per week, X_1,...,X_n =Explanatory variables, μ=Error term

The explicit form of the multiple regressions is expressed as follows:

$$Q = f\ (\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \mu\ ) \ldots\ldots\ldots (8)$$

Where:

Q=Number of crates of eggs per week, β's= The parameters to be estimated, β_o=Constant, X_1= Age of farmer (years), X_2= Level of education (years), X_3= Household size (no. of persons), X_4= Farming experience (years), X_5= Stock size (no. of birds), X_6= Age of birds (no of weeks), X_7=Qty of feed (kg), μ=Error term

Results and Discussion

Socio-Economic characteristics of Respondents

Age of Respondents

The results of Table.2 indicated that the mean age of farmers keeping birds in battery cage, deep litter and both technologies were 42, 45 and 49 years respectively. This means that a good number of poultry farmers are still in their active age bracket. This could be because younger farmers whose age falls below 29 years may be constrained by funds to start up a layer enterprise. This is in line with the findings of Ayinde *et al.* (2012) who reported that majority of poultry operators in Ogun State Nigeria operating under Battery cage, deep litter and both technologies respectively were below 29 and 49 years old.

Gender

The Majority of the egg farmers (64%, 81.7% and 66.7%) in battery cage, deep litter and both systems respectively were male. This could be linked to the fact that males have greater access to funding than their female counterpart. A similar findings was reported by Okonkwo and Ahaotu (2019).

Marital Status
The study also showed that 70.9%, 76.7% and 88.8% of the respondents in battery cage, deep litter and both technologies were married implying married people can work together as a team, which can effectively manage various aspects of the business, such as farm operations, financial management, and marketing. This is in agreement with the study by Esiobu *et al.* (2014) who asserted that the majority (76.67%) of the poultry egg farmers in Imo State were married meaning they are responsible individuals by the standards of the society.

Poultry Farming Experience
The mean years of poultry farming experience were 9, 10 and 13 years for battery cage deep litter and those using both technologies respectively. The years of poultry experience affect output positively as more experienced farmers tend to be more knowledgeable and skilled in poultry management.

Household Size
Mean household size was found to be 6, 5, and 4 persons for battery cage deep litter and both technologies. Household size influences egg production by contributing to family labour which reduces cost of production.

Education
The majority of the farmers using battery cage and a combination of both systems (73.3% and 88.8%) had tertiary education as against the deep litter producers that had majority (23 %) of the farmers with secondary school education. This could be explained by the fact that formal education enhances the rate of adoption of improved technologies. Okonkwo and Ahaotu (2019) reported that 74.4 % of the battery cage and 51% of the deep litter farmers have post – secondary education and by implication, more literate farmers operate in battery cage production.

Primary Occupation
The primary occupation of egg farmers for battery cage, deep litter and both systems was found to be mostly poultry farming at 35.5%, 43.3% and 44.4% respectively. Meaning that poultry farming to them is a full- time business that requires their time and focus.

Distribution of Farmers by Scale of Operation
The result from Table.3 shows the distribution of farmers on scale of operation. Medium-scale operation recorded the highest percentage in all three farm technological practicess with 45.2%, 50.0% and 66.6% in battery cage, deep litter and both systems respectively. This is contrary to the findings of Effiong and Umoh (2010) who noted that the poultry enterprise in Akwa Ibom State is dominated by small-scale farmers and is regarded as major contributor to the growth of the sector in the state. The categorization was done based on what was reported by Omotosho and Oladele (1988), Subhash, Joynal and Fakhrul (1999) and Ojo (2003), they reported that poultry egg farmers having less than 1000 birds were considered as small-scale farmers, 1001-3000 as medium-scale farmers while those having 3000 and above birds were large scale farmers.

Average Stock Size for Small, Medium and Large Scale Operation in the Study Area
Table 4 presents the average stock size of birds in the study area. The result revealed that the average stock size in battery cage, deep litter and farmers keeping birds in both technologies were 2176, 2091 and 2155 respectively. Farmers who employed battery cage had the highest number of birds stocked. By implication these categories of poultry farmers appear to have a good financial base to be able to maintain the birds.

Average Quantity of Eggs in Crates Produced Per Week
The average weekly quantity of eggs from Table .5 shows that under battery cage, deep litter and both systems for small-scale producers, the number of eggs obtained were 119.5, 102.5 and 140.4 crates per week, the medium-scale had 329.8, 304.3 and 292.8 crates, while large scale farmers recorded 475.3, 473.8 and 470.2 crates respectively. The average quantity of eggs in battery cage, deep litter and both technologies were 308.2, 293.5 and 301.1 crates weekly implying that eggs obtained from battery cages are higher than in other technologies. This could not possibly be far from the reduced quantity of cracked eggs that is obtainable in the battery cage technology.

Analysis of Gross Margin and Net Farm Income for Poultry Egg Production in the Study Area
The result of the data analysed and presented in Table 6 shows that the total variable cost in battery cage technology for small, medium and large scale operations were ₦13, 280,790.00, ₦36, 132, 733.00 and ₦50, 963 146.00 respectively. The pooled value was found to be ₦33, 458,889.00. The cost of feed accounted for the highest proportion of total variable cost at 92% which is in agreement with the findings of Ashagidigbi, Sulaimon, and Adesiyan (2011) who reported that the cost of feeding laying birds accounted for over 70 per cent of the total cost of production. The total revenue generated from battery cage for the small, medium and large scale were ₦15,598,756.00, ₦43,445,689.00 and ₦63,158,030.00 respectively. Revenue from eggs accounted for the highest proportion of revenue while the revenue from manure accounted for the least. The gross margin in small, medium and large scale was ₦2,317,966.00, ₦7,312, 956.00 and ₦12,194,884.00 respectively with an average value of ₦7,275,268.00. The gross margin per bird was found to be ₦3175.00, ₦3373.00, ₦3613.00 with a pooled value of ₦3387.00. The profit for battery cage technology in the study area was ₦1,932,133.00, ₦6,329, 762.00 and ₦11,076,927.00 for small, medium and large scale categories with an average of ₦6, 446, 274.00. The rate of return on investment was 14.14 %, 17.05% and 21.27% for all three scales of production with an average of 17.49%.

The total variable costs from Table 7 were found to be ₦11,010,045.00, ₦34,407,358.00 and ₦54,778,726.00 for small, medium and large scale operations

respectively in deep litter technology with a pooled value of ₦33, 398,709.00. The cost of feed accounted for 90% of the total cost. Total fixed cost was ₦234,500.00, ₦825960.00 and ₦974, 000.00 for small, medium and large scale productions respectively with an average of ₦678,153.00 and the total cost of production was ₦11244,545.00, ₦35,233,318.00 and ₦56,752,726..00 for small, medium and large scale production respectively with a pooled value of ₦34,410,196 .00. The total revenue generated in small, medium and large scale production for deep litter system were ₦12,993,483.00, ₦40,512,549.00, and 65,284,653.00 respectively. The gross margins were ₦1,983,438.00, ₦6,105,191.00, and ₦10,505,927.00 for small, medium and large scale production respectively and the gross margin per bird were ₦2,717.00, ₦2,816.00 and ₦3,113.00. for small, medium and large scale production respectively. The pooled value for the gross margin per bird was ₦2,964.00. The average rate of return on investment was 13.93%.

Analysis of Gross Margin and Net Farm Income of Farmers using Both Deep Litter and Battery Cage Technologies in the Study Area

The results from Table 8 shows that the total variable cost for farmers using both deep litter and battery cage technologies were ₦14,956,400.00, ₦31,750,865.00 and ₦50,072,110.00 for small, medium and large scale operations respectively. The pooled total variable cost, total fixed cost and total costs were ₦31,843,123.00, ₦642,433.00 and ₦32,480,557.00.respectively. The Cost of feed accounted for 93% of the total variable cost. The results show that the total revenue for small, medium and large scale operators were ₦16,817,889.00, ₦37,297,428.00 and ₦60,437,778.00 for farmers using both battery cage and deep litter. Gross margin was found to be ₦2,646,489.00, ₦5,991,567.00and ₦10,400,668.00 with a pooled value of ₦6,346,241.00. The gross margin per bird was ₦2,646.00, ₦2,830.00 and ₦3,104.00 for small, medium and large scale operators respectively with a pooled value of ₦2,860.00.

The summary of the results as presented in Table 9 shows that the average stock size in the study area in deep litter and battery cage were 2176 and 2091 birds. The total variable cost (TVC) in the battery cage was ₦33,458,889.00 while that of deep litter technology was ₦ 33,398709.00. The total revenue was ₦40, 734, 158.00 in battery cage and ₦39,596, 894.00 for deep litter with profit of ₦6,446,274.00 and ₦5,186,698.00 in battery cage and deep litter respectively. Gross margin were ₦7337,756.00 and ₦6,198,185.00 for battery cage and deep litter respectively. This means that poultry business in both technologies were profitable in the study area as they all had positive gross margins. The gross margins per bird for battery cage and deep litter technologies were ₦3387.00 and ₦ 2964.00 respectively. Rate of return on investment (RROI) was used to determine the profitability of the business in the study area. Rate of return on investment was found to be 17.49% and 13.93% under battery cage and deep litter technologies. This implies that for every one naira invested in the battery cage system and deep litter technologies, returns of ₦17.49 and ₦13.93 is generated in battery cage and deep litter respectively. This means that keeping birds under battery cage of management was more profitable. This is in agreement with a study by Akinyemi, Okuneye, and Hosu (2015) on the profit efficiency of poultry egg production system in Ogun State, Nigeria. He reported that battery cage system was more profitable than deep litter system with average profit of the farmers being ₦1,782,750.00 compared with ₦491,350.00 in deep litter. The rate of Returns on Investment (ROI) of battery cage system was 17.07% while that of the deep litter system was 9.05%.

Factors affecting egg output in deep litter and battery cage technologies

The regression results of the factors affecting the quantity of eggs produced are presented in Table 10. The linear model was chosen as the lead equation. The number of significant variables, the signs of the regression coefficients, magnitude of the coefficients of multiple determination were satisfactory. The results showed that experience (α 0.01), stock size (α 0.01), education (α 0.1), and age of birds (α 0.01), had a significant relationship with the quantity of eggs produced for both systems. The R^2 value of 0.9964 indicates that 99% of the variation in the dependent variable (quantity of eggs produced) is caused by the independent variables.

Farming Experience

Experience had a positive relationship with quantity of eggs produced at a 1% level of significance. This is as expected because experienced farmers have the technical and managerial know-how to operate the business profitably. The magnitude of the coefficient signifies for a unit increase in years of experience, egg output will increase by 1.03 units.

Stock size

Stock size had a positive relationship with the number of eggs produced at a 1% level of significance. This is also as expected because as a farmer increases the quantity of birds, the quantity of eggs also increases.

Education

Education was negatively related to output at 10% level of significance. The magnitude of the coefficient signifies that a unit increase in educational level reduces output by 0.35 units. Implying that factor such as native intelligence enable farmers to increase their volume of eggs though they may not be educated. This is in agreement with the work of Ayinde *et al.* (2012) who postulated that formal education may just be a necessary but not sufficient reason for increased egg production.

Age of birds

The age of birds had a negative relationship with the quantity of eggs produced. It was statistically significant at a 5% level. The magnitude of the coefficient of age of birds implies that for a unit increase in the age of birds, the volume of eggs produced reduces by 0.18 unit. This

is not surprising because as the birds get older the percent lay of eggs also reduces irrespective of the management practice or medication administered. This is a result of old age.

Conclusion

Battery cage system is more expensive than deep litter system because of the huge capital outlay arising from the cost of procuring battery cages. Majority of the farmers in Akwa Ibom State are employing deep litter systems and operate at medium scale (1001 – 3000 birds) capacity. This is because of the huge capital cost of acquiring battery cage. Egg production in battery cages, deep litter and a combination of both technologies were all profitable as they all had positive gross margins. Comparatively, battery cage was more profitable than deep litter as it had a higher gross margin per bird. Age of the farmer, farming experience, education and age of birds were significant variables affecting quantity of eggs produced irrespective of technology employed. It is recommended that poultry farmers should be encouraged to adopt battery cage technology. Grants and loan facilities at low interest rates should be provided to poultry farmers to enhance production of eggs under battery cage technology. Farmers should be trained on how to produce their poultry feed with locally available feed ingredients to reduce feed costs.

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Table 1: Number (50%) of Poultry Farmers under Different Technologies in the Study Area

Local Government	Battery cage	Deep Litter	Both
Uyo	15	31	5
Abak	9	17	2
IkotEkpene	7	12	2
Total	31	60	9

Source: Data generated by the researcher in 2022

Table 2: Socio-Economic Characteristics of Respondents

Variables	Battery cage farmers only		Deep litter farmers only		Farmers using both technologies	
AGE	Freq	%	Freq	%	Freq	%
20 – 29	1	3.2	2	3.3	0	0.0
30 – 39	11	35.5	6	10	1	11.1
40 – 49	16	51.6	42	70	4	44.4
50 – 59	2	6.5	9	15	3	33.3
60 – 69	1	3.2	1	1.7	1	11.1
Total	**31**	**100**	**60**	**100**	**9**	**100**
Mean Age	42		45		49	
Gender						
Male	20	64.5	49	81.7	6	66.7
Female	11	35.5	11	18.3	3	33.3
Total	**31**	**100**	**60**	**100**	**9**	**100**
Marital Status						
Single	4	12.9	6	10	0	0.0
Married	22	70.9	46	76.7	8	88.8
Widowed	4	12.9	4	6.7	1	11.1
Divorced	1	3.2	4	6.7	0	0.00
Total	**31**	**100**	**60**	**100**	**9**	**100**
Farming Experience (Years)						
1 – 5						
6 – 10						
11 – 15	12	38.7	0	0.0	0	0.0
16 – 20	7	22.6	8	13.3	1	11.1
21 - 25	10	32.3	24	40	7	77.7
Total	1	3.2	26	43.3	1	11.1
Mean	1	3.2	2	3.3	0	0.0
	31	**100**	**60**	**100**	**9**	**100**
	9		10		13	
Household Size						
1-3	2	6.5	11	18.3	3	33.3
4-6	20	64.5	39	65	5	55.6
7-9	9	29.0	10	16.7	1	11.1
Total	**31**	**100**		**100**		**100**
Mean	6		5		4	
Level of Education						
No formal education	0	0	7	11.7	0	0.0
Primary Sch Edu	1	3.2	8	13.3	0	0.0
Secondary School	2	6.4	14	23.3	1	11.1
Tertiary	28	89.4	31	51.6	8	88.8
Mean	**16**		**12**		**17**	22.2
Total	**31**	**100**	**60**	**100**	**9**	**100**
Primary Occupation						
Poultry farming						
Crop farming	11	35.5	26	43.3	3	33.3
Trading	6	19.4	9	15	1	11.1
Civil service	4	12.9	7	11.7	1	11.1
Total	10	32.3	18	30	4	44.4
	3`	**100**	**60**	**100**	**9**	**100**

Source: Field Survey, 2022

Table 3: Distribution of Farmers by Scale of Operation in the Study Area

Scale of operation	Battery cage		Deep litter		Both technologies	
	Freq	**%**	**Freq**	**%**	**Freq**	**%**
Small (<1000)	6	19.4	20	33.3	1	11.1
Medium(1001- 3000)	14	45.2	30	50.0	6	66.6
Large (>3000)	11	35.5	10	16.6	2	22.2
Total	31	100	60	100	9	100

Source: Field survey 2022

Table 4: The Average Stock Size for Small, Medium and Large -Scale Operations in the Study Area

Scale of operation	Battery cage	Deep litter	Both technologies
	Average stock size	Average stock size	Average stock size
Small	850	730	1000
Medium	2350	2168	2117
Large	3321	3375	3350
Average for each system	2176	2091	2155

Source: Field survey 2022

Table 5: Average Quantity of Eggs in Crates Produced Per Week

Scale of operations	Battery cage (Av. Crates per week)	Deep litter (Av. Crates per week)	Both technologies (Av. Crates per week)
Small scale	119.5	102.5	140.4
Medium scale	329.8	304.3	292.8
Large scale	475.3	473.8	470.2
Average	308.2	293.5	301.1

Source: Field survey 2022

Table 6 Analysis of Cost Structure and Returns for Battery Cage Technology for one production cycle (18 months) in the Study Area

Variables	Small-Scale qty 850 birds Amt (₦)	Medium- Scale qty 2350 birds Amt(₦)	Large Scale qty 3321 birds Amt (₦)	Pooled value Average qty 2176 birds Amt (₦)	Per cent contribution to TC (%)
Cost of DOC	328,500.00	975,600.00	1,518,750.00	940,950.00	2.64
Feed	12,025,250.00	33,422,750.00	47,363,545.00	30,937,181.00	90
Transportation	67,968.00	79,285.00	95,454.00	80,902.00	0.24
Medication	138,333.00	249,642.00	296818.00.00	193,987.00	0.57
Vaccination	148,333.00	285,714.00	546,363.00	326,803.00	0.95
Labour	235,000.00	515,714.00	810,909.00	520,541.00	1.42
Mortality	24,240.00	56,388.00	88,581.00	6,403.00	0.15
Electricity bill	120,000.00	147,142.00	153,181.00	140,107.00	0.4
Fuel	50,000.00	228,571.00	200,000.00	159,523.00	0.36
Repairs/maintenance	115,000.00	127,142.00	130,000.00	124,047.00	0.35
Disinfectant	8,166.00	9,285.00	10,000.00	9,150.00	0.03
Kerosene/Charcoal	20,000.00	35,500.00	46,363.00	33,954.00	0.1
Total Variable Cost	**13,280,790.00**	**36,132,733.00**	**50,963,146.00**	**33,458,889.00**	
TVC per bird	**15,624.00**	**15,376**	**15,346.00**	**15,376.00**	
Fixed Cost Items					
Depreciation values	282,500.00	728,909.00	840,685.00	617,364.00	2.05
The rental values of land	103,333.00	254,285.00	277,272.00	211,630.00	0.75
Total fixed cost	385,833.00	983,194.00	1,117,957.00	828,994.00	
Total Cost	**13,666,623.00**	**37,115,927.00**	**52,081,103.00**	**34,287,884.00**	**100**
Revenue Items					
Eggs	12,265,200.00	33,840,000.00	48,763,636.00	31,622,945.00	
Spent layers	1,904,300.00	5,643,100.00	8,781,300.00	5,442,900.00	
Poultry Manure	1,435,556.00	3,968,889.00	5,619,394.00	3,674,613.00	
Total Revenue	15,605,056.00	43,451,989.00	63,164,330.00	40,740,458.00	
Gross Margin	**2,317,966.00**	**7,312,956.00**	**12,194,884.00**	**7,275,268.00**	
GM Per Bird	**3,175.00**	**3,373.00**	**3,613.00**	**3,387.00**	
Profit	**1,932,133.00**	**6,329,762.00**	**11,076,927.00**	**6,446,274.00**	
RROI	**14.14%**	**17.05%**	**21.27%**	**17.49%**	

Source: Field survey, 2022

Table 7: Analysis of Cost Structure and Returns for Deep Litter Technology for one production cycle (18months) in the Study Area

Items	Small Scale qty 730 birds Amt (₦)	Medium Scale qty 2168 birds Amt(₦)	Large Scale qty 3375 birds Amt (₦)	Pooled value 2091 birds Amt (₦)	Percent contribution to TC (%)
Variable cost					
Cost of DOC	332,150.00	986,440.00	1,535,625.00	951,405.00	2.76
Feed	10,124,930.00	31,831,275.00	50,852,934.00	30,936,379.00	89.9
Transportation	97,500.00	155,000.00	299,000.00	183,833.00	0.53
Medication	75,700.00	200,333.00	250,000.00	175,344.00	0.50
Vaccination	90,950.00	400,000.00	600,000.00	363,650.00	1.05
Labour	50,500.00	400,000.00	600,000.00	350,166.00	1.01
Mortality	19,865.00	56,810.00	90,667.00	55,780.00	0.16
Electricity bill	50,000.00	120,000.00	145,000.00	105,000.00	0.30

Fuel	65,000.00	85,000.00	120,000.00	90,000.00	0.26
Repair/maintenance	26,450.00	39,500.00	50,000.00	38,650.00	0.11
Disinfectant	15,650.00	20,100.00	30,000.00	21,916.00	0.06
Wood shavings	45,600.00	71,000.00	150,000.00	88,866.00	0.25
Kerosene/Charcoal	15,750.00	41,900.00	55,500.00	37,716.00	0.10
TVC	11,010,045.00	34,407,358.00	54,778,726.00	33,398,709.00	
TVC Per Bird	15, 082.00	15,870.00	16,230.00	15,972.00	
Fixed Cost Items					
Depreciation value	100,000.00	571,960.00	684,000.00	451,199.00	1.31
Rental value of land	134,500.00	254,000.00	290,000.00	226,166.00	0.65
Total Fixed Cost	**234,500.00**	**825,960.00**	**974,000.00**	**678,153.00**	
Total Cost	**11,244,545.00**	**35,233,318.00**	**56,752,726.00**	**34,076,858.00**	100
Revenue Items					
Eggs	9,861,750.00	30,313,675.00	49,608,640.00	29,928,021.00	
Spent layers	1,898,000.00	5,636,800.00	8,775,000.00	5,436,600.00	
Manure	1,233,733.00	4,562,074.00	6,901,013.00	4,232,273.00	
Total Revenue	12,993,483.00	40,512,549.00	65,284,653.00	39,596,894.00	
Gross Margin	1,983,438.00	6,105,191.00	10,505,927.00	6,198,185.00	
GM Per Bird	**2,717.00**	**2,816.00**	**3,113.00**	**2,964.00**	
Profit	1,748,938.00	5,279,231.00	8,531,927.00	5,520,036.00	
RROI	14.24%	13.75%	13.81%	13.93%	

Source: Field survey, 2022

Table 8: Analysis of Gross Margin and Net Farm Income of Farmers using Both Deep Litter and Battery Cage Technologies in the Study Area

Variables	**Small -Scale qty (<1000) Average qty 1000 birds Amt (₦)**	**Medium- Scale qty (1001 - 3000) Average qty 2117 birds Amt(₦)**	**Large Scale qty (>3000) Average qty 3350 birds Amt (₦)**	**Pooled value Average qty 2155 birds Amt (₦)**	**Per cent contribution to TC (%)**
Cost of DOC	320,000.00	677,440.00	1,072,000.00	689,813.00	2.17
Feed	13,265,000.00	29,199,005.00	46,787,750.00	29,750,585.00	93.43
Transportation	40,000.00	173,333.00	350,000.00	187,777.00	0.59
Medication	60,000.00	215,000.00	450,000.00	241,666.00	0.76
Vaccination	60,000.00	145,833.00	230,000.00	145,277.00	0.46
Labour	240,000.00	451,666.00	480,000.00	390,555.00	1.23
Mortality	22,400.00	47,420.00	47,360.00	39,060.00	0.12
Electricity bill	60,000.00	103,333.00	150,000.00	104,444.00	0.33
Fuel	40,000.00	200,166.00	300,000.00	180,055.00	0.57
Repair/maintenance	30,000.00	27,500.00	60,000.00	39,166.00	0.12
Disinfectant	10,000.00	10,333.00	40,000.00	20,111.00	0.06
Wood shavings	24,000.00	14,166.00	20,000.00	19,388.00	0.06
Kerosene/Charcoal	15,000.00	40,666.00	50,000.00	35,222.00	0.11
Total variable cost	**14,171,400.00**	**31,305,861.00**	**50,037,110.00**	**31,843,123.00**	**100.00**
Fixed cost items					
Depreciation value	170,000.00	572,300.00	700,000.00	480,767.00	
The rental value of land	150,000.00	155,000.00	180,000.00	161,667.00	
Total fixed cost	**320,000.00**	**727,300.00**	**880,000.00**	**642,433.00**	
Total Cost	14,491,400.00	32,033,161.00	50,917,110.00	32,480,557.00	
Revenue from eggs	13,400,000.00	29,041,250.00	47,240,000.00	29,893,750.00	
Spent layers	2,409,000.00	5,080,800.00	8,040,000.00	5,176,600.00	
Manure	1,008,889.00	3,175,378.00	5,157,778.00	3,114,015.00	
Total Revenue	**16,817,889.00**	**37,297,428.00**	**60,437,778.00**	**38,184,365.00**	
Gross Margin	**2,646,489.00**	**5,991,567.00**	**10,400,668.00**	**6,346,241.00**	
GM Per Bird	**2,646.49.00**	**2,830.00**	**3,104.00**	**2,860.00**	
Profit	**2,326,489.00**	**5,264,267.00**	**9,520,668.00**	**5,703,808.00**	
RROI	16.05%	16.43%	18.70%	17.06%	

Source: Field survey 2022

Table 9: Comparative analysis of the profitability of egg production in battery cage and deep litter technologies in the study area

Variables	Battery cage Pooled value (₦)	Deep litter Pooled value(₦)
Average stock size	2176	2091
Total variable cost	33,458,889.00	33,398,709.00
Total fixed cost	828,994.00	678,153.00
Total cost	34,287,884.00	34,076862.00
Total revenue	40,740,458.00	39,596,894.00
Gross margin	7,275,268.00	6,198,185.00
Profit	6,446,274.00	5,186,698.00
Gross margin per bird	3387.00	2,964.00
Rate of return on investment	17.49%	13.93%

Source: Field survey 2022

Table 10: Regression Estimates of factors affecting output of egg production in both battery cage and deep litter technologies in the study area

Variables	Linear	Double log	Semi log	Exponential
Constant	4.30864 (0.5655)	−0.826846 (0.0001)***	1.83587 (0.0001)***	−21593.9 (0.0001)***
Age	−0.157969 (0.3079)	−0.00788076 (0.6810)	−0.00304479 (0.0264)**	2202.86 (0.0606)*
Education	−0.350788 (0.0630)*	−0.00362532 (0.3222)	0.00235025 (0.1532)	−0.857318 (0.996)
Household size	0.708468 (0.2214)	0.00294409 (0.7120)	0.00143457 (0.7765)	54.6831 (0.9100)
Experience	1.03286 (0.0001)***	0.0128333 (0.0852)*	0.00505645 (0.0255)**	−737.963 (0.1026)
Stock size	0.146640 (0.0015)***	1.08311 (0.0001)***	0.000183787 (0.6406)	20430.3 (0.0066)***
Age of birds	−0.155968 (0.0070)***	−0.0100109 (0.2582)	0.00140021 (0.0058)***	−726.549 (0.1769)
Feed	−0.00221036 (0.9081)	−0.0765921 (0.5136)	2.91452e-05 (0.8619)	−11543.3 (0.106)
R-squared	0.996703	0.998564	0.933372	0.927209
Adjusted R-squared	0.996452	0.998455	0.928303	0.921671

Source: Computed from field data 2022 using gretl
****Significant at 10% level, **Significant at 5% level, ***Significant at 1% level. Va lues in parentheses are p-value***