ARID ZONE JOURNAL OF ENGINEERING, TECHNOLOGY & ENVIRONMENT
AZOJETE September 2020. Vol. 16(3):531-542
Published by the Faculty of Engineering, University of Maiduguri, Maiduguri, Nigeria.
Print ISSN: 1596-2490, Electronic ISSN: 2545-5818
www.azojete.com.ng

ORIGINAL RESEARCH ARTICLE

PRODUCTIVITY AND ALLOCATIVE EFFICIENCY OF QUAIL (CORTUNIX COTURNIX JAPONICA) PRODUCTION USING DIFFERENT REARING TECHNIQUES IN NIGERIA

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ARTICLE INFORMATION

Submitted 20 Sept., 2019
Revised 24 May, 2020
Accepted 30 May, 2020

Keywords:
quail chick
return on investment
allocative efficiency
Profit
technology

ABSTRACT

Small scale poultry production plays a major role in bridging the protein deficit and sustain rural livelihood in Nigeria. This study assesses the productivity and allocative efficiency (AE) of quail (Cortunix coturnix japonica) production using different rearing techniques in Nigeria. In this study, both primary and secondary data were collected from 193 quail poultry farmers comprising of 78 battery cage system (BCS) and 115 deep litter system (DLS) operators using a multi-stage random sampling procedure. Descriptive statistics, profitability indices and stochastic frontier function were used to analyse the data. The stochastic frontier cost function was used to estimate the factors influencing AE of farmers in quail production. The results show a gross margin of N1, 455.51, net poultry returns of N1157.47 per quail bird for BCS thrives better compared to N800.00 and N751.96 estimated in DLS respectively. The estimated profit margin (26.81 %) and return on investment (1.37) in BCS were also higher than 26.54 % and 1.36 respectively in DLS. The ROI result indicates that a N1.00 investment in BCS and DLS yields N0.37 and N0.36 respectively. AE results revealed that the coefficient of costs of feed (0.287), hired labour (-0281), family labour (0.309) and depreciation of fixed items (-005) were found to be statistically significant variables in BCS quail production. Conversely, costs of feed (0.109), cost of hired labour (-0.007) and family labour (0.188) statistically influence DLS quail production. The inefficiency sources model for BCS showed that age, formal education, access to credit and investment are the significant factors. Furthermore, formal education, access to production credit and level of investment contributed significantly to the explanation of efficiency in DLS production unit. Therefore, it is suggested that quail farmers should strive to optimize efficient use of inputs to increase output and profit. This will be an impetus to achieving sustainable poultry production in the studied areas.

1.0 Introduction

Poultry has been domesticated for thousands of years as archaeological evidence suggests that domesticated chickens existed in China 8,000 years ago (Alders 2004) when humans ceased to be hunter-gatherers (Burt, 2007). Domestic chickens appeared in Africa many centuries ago, which are now part of African life (Copland and Alders, 2005). The Red Jungle Fowl is thought to be the source of all poultry (Fumihito et al., 1994).

Over the last decades' poultry production and its technology in Nigeria has been increasingly improved. For example, Food and Agriculture Organisation (FAO, (2018) observed that poultry meat production has increased from 30,000 in 1961 to 201,493 tons in 2017 with standard deviation of 67,351.8 tons and about 571.6 % increased. Over the same period, poultry egg production has increased by 588% (Figure 1). Furthermore, the volume of feed used in Nigeria has increased by 600% from 300 thousand to 1.8 million tons in about one decade and this is driven both by massive investments in large feed mills in southwest Nigeria and a growing number of small and medium enterprises in poultry production scattered around the country (Liverpool-Tasie et al., 2017).

Therefore, Nigeria had a success in poultry production trend and high demand due to rapid population growth. This is also couple with its ability to supply protein rapidly in the short-run. A cursory examination of FAO data computed in Figure 1 shows that poultry and ruminant production has been dwindling in recent year (2011-2017) compared to mono-gastric (pig) and total meat production. This is envisaged due to effect of insurgence in the north eastern part of the country and multi-various farmers-herdsmen, cattle rustling and banditry spreading across the six geopolitical zones in the country. Several studies also have indicated that the north has more of the small farmers' poultry, particularly chicken holdings compared to the south (Liverpool-Tasie et al., 2017).

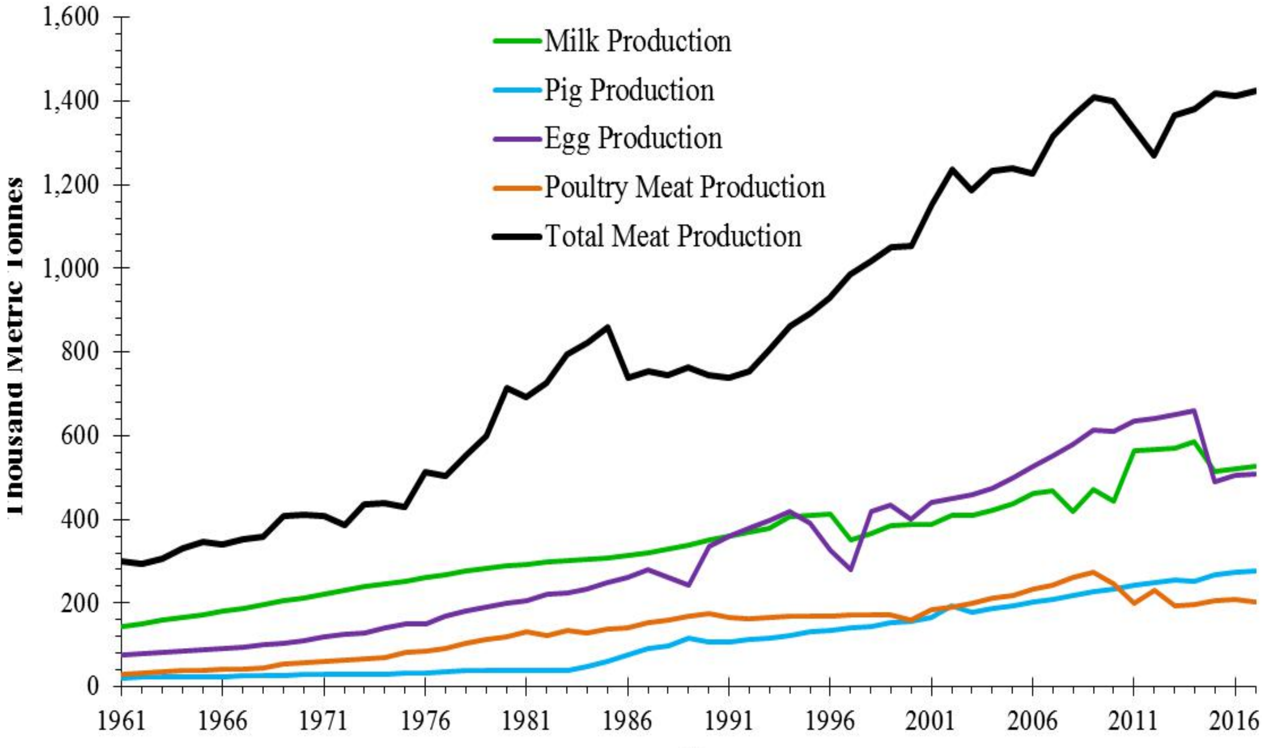


Figure 1: Trend of poultry egg and total meat production in Nigeria (1961-2017); Source: Authors computation from FAO Statistic data (2017)

The poultry industry in Nigeria has hitherto been dominated by rearing of domestic chickens. However, recently there have been several entrants into the sector. Interestingly, one of the poultry species gradually gaining prominence is the Japanese quail (Cortunix coturnix japonica) of Galliformes family which is suitable for commercial rearing under intensive management (Egbeyale et al., 2013). Quail production is considered as a viable and feasible alternative means of livelihood for the unemployed and civil servants. It is an important income-generating strategy for both urban and rural farmers with a supplementary income. Nationally, there is deficiency of animal protein security, with the consumption put at about less than 10g / caput / day as against the daily intake of 65g recommended by the FAO to be the minimum requirement for the growth and development of the body (Odunsi et al., 2007; Mailafia et al., 2010; El-Katcha et al., 2015; Mohammed and Ejiofor, 2015). Consequently, boosting the poultry industry with a short generation interval is an alternative means of alleviating the deficiency of animal protein in Nigeria.

It was, therefore, expedient and imperative to accumulate data on productivity and profitability of quail production in Nigeria for analysis geared towards meaningful policy formulation for the poultry sub-sector especially emerging quail production in the country. It was also essential that to have in-depth knowledge on quail production for being a laboratory animal for poultry and biomedical research. This is in addition to it is being commercially exploited for production of meat and eggs recently in Nigeria. The objective of this study is to describe the socio-economic status of quail farmers, estimate the profitability, analyze the productivity and allocative efficiency of quail (Cortunix coturnix japonica) production using different rearing techniques in Nigeria.

2.0 Material and Methods

2.1 The Study Area

The study was conducted in southwest (Oyo, Ekiti, Ondo States) and north-central (Kwara, Kogi States) Nigeria. This was crucial because the two regions are the main production of quail birds. Nigeria lies between Longitudes 2°49' E and 14°37' E and Latitudes 4°16' N and 13°52' North of the Equator (Oladimeji, 2018). The climate is tropical, characterized by high temperature and humidity as well as marked wet and dry seasons, though there are variations between South and North. It has a total land area of 923,768.6 km^2 and 139 million people in 2006 (NPC, 2006) and the latest United Nation estimate in year 2019 at growth rate of 2.48% (United Nation, UN 2019) put the country over 190 million people with average human density of 204 person km-2. Total rainfall decreases from the coast northwards. The south (below latitude 8°N) has an annual rainfall ranging between 1,500 and 4,000 mm and the extreme north between 500 and 1000 mm. The research was carried out in two geopolitical zones and five states in Nigeria viz: Kwara and Kogi states from north-central and Oyo, Ekiti and Ondo states from southwest of Nigeria.

2.2 Data Collection and Sampling Procedure

Both primary and secondary data were collected from 193 quail poultry farmers using structured questionnaire with personal interview method by trained enumerators. Secondary data were collected from the production records of the quail farmers. Primary data compliment with their records were search for and these include inputs data such as human labour, quantity of feed, water and fuels used. Output data collected include quail meat, egg and manure.

The collected data belonged to the 2016/2017 production year. Before collecting data, a pre-test survey was conducted from a group of randomly selected quail poultry farmers in the two sampled regions. Information on socio-economic and institutional characteristics, input and output, energy input sources were obtained from the quail farmers to achieve the objectives of study.

Multistage sampling procedure was adopted for the study. The first stage involved purposive selection of two regions comprising north central (Kwara and Kogi states) and south western (Oyo and Ekiti/Ondo states) Nigeria due to predominance of poultry farmers and, availability of quail production records among the poultry farmers. The list of registered cooperative poultry farmers was obtained in the states' Agricultural Development Project (ADP). Thereafter, stratified sampling technique was used to sieve the quail poultry farmers from layers and broilers poultry farmers. Thereafter, all the sieved quail farmers were sampled due to small sample size. Finally, additional quail farmers were sought for using snowball-sampling technique based on information from sampled farmers. This means that initially selected quail poultry farmers from ADP group provided addresses of additional quail farmers who were neither a cooperative member nor a registered poultry farmer with ADP for their interviewers (Salganik and Heckathorn, 2014; Oladimeji et al., 2019). A total of 193 quail farmers comprising of 78 battery cage system (BCS) users and 115 deep litter system (DLS) users were sampled in the chosen states.

2.3 Analytical Technique

Descriptive statistics, profitability indices and stochastic frontier function were used to analyse the data. The stochastic frontier cost function was used to estimate the factors influencing allocative efficiency of farmers in quail production adopted from Aigner et al. (1977), Battese et al. (1996) and Oladimeji et al. (2017).

Stochastic Allocative Function Model used in the study was specified explicitly as

$$Y = \alpha + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + V - U \quad (1)$$

Where: = natural log; Y = total cost of production (₦/bird); X_1 = cost of feed (₦); X_2 = cost of quail chick (₦); X_3 = cost of hired labour used (₦); X_4 = cost of family labour (₦); X_5 = cost of vaccine and drugs (₦), $X_6 =$ depreciation cost of machinery which include electricity, generator, fuels, borehole, electric motor, steel and battery (₦); $\beta_1 - \beta_6$ = regression coefficients; V_1 = random variability in the production that cannot be influenced by the quail producers.

$-U_i$ = deviation from maximum potential output attributable to allocative inefficiency.

$$-U_i = \delta_o + \delta_1 \ln Z_1 + \delta_2 \ln Z_2 + \delta_3 \ln Z_3 + \delta_4 \ln Z_4 + \delta_5 \ln Z_5 + \delta_6 \ln Z_6 + U \quad (2)$$

Where: $-U_i$ = allocative inefficiency effects, Z_1 = age of farmers (years), Z_2 = household size (number), Z_3 = formal education (years), Z_4 = poultry rearing experience (years), Z_5 = access to credits (₦); Z_6 = level of investment (₦); δ_o = constant and $\delta_1 - \delta_6$ = parameters to be estimated (Aigner et al., 1977; Battese et al., 1996).

The profitability indices involved the estimating the following items:
Net Farm Income for quail poultry production was estimated using equation below:

$$NFI = \left(\sum_{I=1}^{M} TR_{IJ}\right)(M_J)^{-1} - \left(\sum_{I=1}^{M} TC_{IJ}\right)(M_J)^{-1} \quad (3)$$

Where: NFI = Net Farm Income per quail bird in the jth states (₦); TR = Total sales revenue accruing to the ith quail farmers per bird in the jth states (₦); TC_{IJ} = Total cost incurred by the ith quail farmers per bird (₦); and M_J = Total number of quail farmers in the jth states.
Total Revenue (TR) is the total return or total value product (the total output multiplied by the price per unit of produce). That is;

$$Q * Py \quad (4)$$

Where; Q = quantity of quail bird (kg) and P_y = price per unit of quail bird (N); Total Cost (TC) was computed using equation below

$$TC_{ij} = TVC_{ij} + TFC_{ij} \quad (5)$$

TVC = Total Variable Cost incurred by the ith quail farmer in the jth states (₦) and TFC = Total Fixed Cost incurred by the ith quail farmer in the jth states (₦).

Profitability indices were also computed as:

$$ROI = \frac{gross \quad income}{total \quad cost} \quad (6)$$

$$PM(\%) = \frac{net\ margin}{gross\ income} * 100 \quad (7)$$

$$GR(\%) = \frac{total\ cost}{gross\ income} * 100 \quad (8)$$

$$\frac{NM}{quail\ bird} = \frac{net\ margin}{average\ output} \quad (9)$$

$$\frac{NM}{TC} = \frac{net\ margin}{total\ cost} \quad (10)$$

Where: ROI = return on investment, PM = profit margin and GR = gross ratio.
$TFC =$ Total Fixed Cost involved depreciated value of equipment used in quail bird rearing expressed as:

$$D = \frac{P-S}{N} \quad (12)$$

Where:
D = depreciation on production equipment (₦), P = Purchase value (₦), S = salvage value (₦) and N = life span of asset (years).

3. Results and Discussion

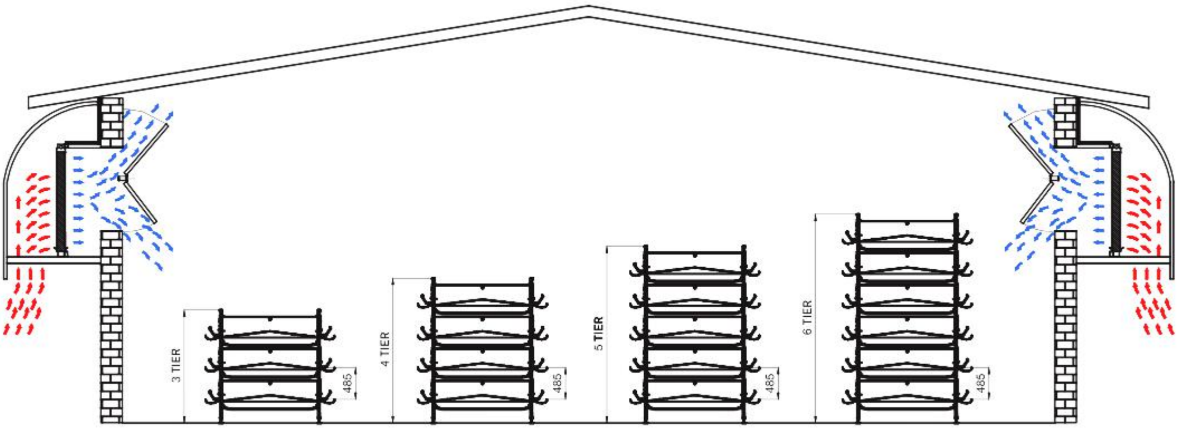
3.1 Technological, Socio-Economic, Institutional Characteristics

Figure 2 depict a typical description of quail battery cage system and Table 1 showed the summary of technological characteristics used in quail production by the sampled farmers. Table 2 summarizes socio-economic and institutional variables employed in the model estimation. The level of technological investment, number of day old chicks acquired by quail poultry farmers and credit accessed for quail rearing revealed that quail production practices are still not developed and are largely subsistent and rudimentary as evidence in Table 1.

Table 1: Description of technology characteristics employed by quail poultry farmers

Technology traits	Type used	Standard
Quail cage	Plank with wire (600 X 600 mm)	Galvanized sheets & wire materials (1200 X 600 mm)
Feed system	Manual with feeder	Automatic feed carriages
Drinking / watering system	Manual drinker	Pipes with nipples
Egg collection system	Manual plastic plate	Automatic egg collection made up of galvanized sheet & wire materials
Manure collection	Manual with shovel	Manure transfer conveyors

Source: Swain et al. 2010



MODEL	TIER	HEIGHT OF CAGE LINE	HEIGHT BETWEEN TIERS
B - 60	3 TIER	1895 mm	485 mm
B - 60	4 TIER	2380 mm	485 mm
B - 60	5 TIER	2865 mm	485 mm
B - 60	6 TIER	3350 mm	485 mm

Figure 2: A typical description of quail battery cage system
Source: Dewulf et al. (2011)

Table 2 indicates that sampled quail farmers were dominated by male (0.67) and married farmers (0.89) with mean age of 48 years and household size of 6.

Table 2: Description and measurement of variables employed in allocative efficiency model

Variables	Unit	Min.	Max.	Mean	Stdev	COV %
Gender (male=1)	dummy			0.67	0.22	32.83
Marital status (married=1)	dummy			0.89	0.09	10.11
Age	years	25	65	48	6.1	12.71
Quail poultry experience	years	1	13	7.4	3.7	50
Level of formal education	years	6	15	12.8	0.3	2.34
Adjusted household size	number	3	11	6	1	16.67
Credit for quail rearing	Naira	0	200,000	61,900.92	34,003.3	43.1
Poultry coop. membership	years	0	7	5	2.04	40.8
Investment in quail production	Naira	12.600	276,000	149,730.0	38,440	25.67
Number of quail birds kept	number	25	500	251	35	13.94
Hired labour per two cycle	man-days	109	201	167	34	20.36
Family labour per two cycle	man-days	54	113	89	21	23.60

Source: Field survey, 2016/2017; m denote million, COV stood for coefficient of variance

This mean age revealed that the quail farmers sampled were agile and productive, an essential ingredients to quail production activities. It is believed that old people tend to adhere strictly to

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traditional methods of poultry, while young people tend to be more willing to adopt new production methods in order to increase production. Therefore, it could be concluded that the preponderance of active and virile poultry farmers in the study area has a multiplier effects on increased availability of able bodied labour for primary production; ease of adoption of innovations; reduction in the degree of risk-aversion and positive implication to sustainability of poultry enterprise in the State. The result is comparable to Oladimeji et al. (2017) on profit efficiency of broiler production among public servant household heads in Kwara State, Nigeria.

3.2 Estimated Profitability Indices and Return to Investment in Quail Production

Table 3 depicts profitability indices and return to investment in battery cage and deep litter quail rearing techniques. The results showed that under battery cage system (BCS), the total variable cost constituted 90.57% while the fixed cost constituted only 9.43% while in deep litter system (DLS), the total variable cost constituted 96.75 %.

The gross margin per quail bird (N1, 455.51), net poultry returns per quail bird (N1157.47) for BCS thrive better compared to N800.00 and N751.96 respectively estimated in DLS. These imply that quail production in BCS is more profitable than DLS. The estimated profit margin (26.81 %) and return on investment (1.37) in BCS were higher compared to 26.54 % and 1.36 respectively in DLS. The ROI result indicates that a N1.00 investment in BCS and DLS yields N0.37 and N0.36 respectively. This, therefore, implies that BCS yielded more returns to investment. The result is comparable to Adelomo and Owoeye (2017) and Bakoji et al. (2013) on economic analysis of quail farming in Southwest and Bauchi State, Nigeria respectively.

Table 3: A summary of profitability indices and return on investment per quail bird per * * 2 cycles

	BCS	DLS	Pooled
Cost item values (₦)			
Total fixed cost	298.04(9.43)	48.04(2.31)	84.79 (3.25)
Total variable cost	2,861.09(90.57)	2,033.25(97.69)	2,523.40(96.75)
Total cost	3,159.13(100.0)	2081.29 (100.00)	2,608.19(100.0)
Average output per bird (Naira)			
Egg sales (₦ 19 per egg)	3,979.6(92.19)	2,550.00(90.00)	3,211.00(90.81)
Spent quail bird sold	287.50(6.66)	222.90(7.87)	270.00(7.64)
Manure	49.50(1.15)	60.35(2.13)	55.09(1.56)
Total revenue(gross income)	4,316.6 (100)	2833.25 (100)	3,536.09 (100)
Gross margin per bird per annum	1,455.51	800.00	1,012.69
Net poultry income / bird / annum	1157.47	751.96	927.90
Profit margin (%)	26.81	26.54	26.22
Return on investment	1.37	1.36	1.36
Gross ratio	73.19	73.46	73.76
Net margin to cost ratio (%)	36.64	36.13	35.58
Number of observations	78	115	193

Source: Field Survey, 2016/2017; production and financial records; * labour consist of cost of hired, family and return to management; * * 2 cycles ranges from 340 – 422 days averaged approximately 365 days; N or ₦ stood for Naira, Nigeria currency

3.3 Estimate the factors influencing Allocative Efficiency of farmers' investment in quail production

Table 4 showed the result of the allocative efficiency (and inefficiency) frontier model of quail production in Nigeria. Allocative efficiency results of BCS quail production revealed that a unit increase in the coefficients of costs of feed ($p < 0.01$), and family labour ($p < 0.05$) will lead to a corresponding increase in total cost by 0.287 and 0.309 units. However, the coefficients of hired labour ($p < 0.05$), and depreciation of fixed items ($p < 0.005$) in BCS quail production will reduced the total cost by 0.281 and 0.005 units respectively. Likewise, results also revealed that a unit increase in the coefficients of costs of feed ($p < 0.01$) and family labour ($p < 0.01$) will lead to a corresponding increase in total cost by 0.109 and 0.188 units respectively of DLS quail production. On the other hand, a unit increase in hired labour ($p < 0.01$) will lead to a unit decrease in total cost by 0.007 units of DLS quail production.

Table 4: MLE Results of allocative frontier efficiency function of quail production

Variables	Battery cage	Deep litter	Pooled
	β |P[|Z|>z]	β |P[|Z|>z]	β |P[|Z|>z]
Cost Function			
Constant	0.003(0.029) **	0.015(0.100)	0.038(0.008) ***
Cost of feed (X_1)	0.287 (0.000) ***	0.109(0.007) ***	0.521(0.000) ***
Cost of quail chick (X_2)	-0.0004(0.521)	-0.061(0.381)	-0.122(0.203)
Cost of hired labour (X_3)	-0.281 (0.029)**	-0.007(0.000) ***	-0.400(0.000) ***
Cost of family labour (X_4)	0.309 (0.019) **	0.188(0.004) ***	0.097(0.005) ***
Cost of vac. and drugs (X_5)	0.002 (0.798)	0.001(0.503)	0.003(0.421)
Dep. of fixed items (X_6)	-0.005 (0.019) **	0.117(0.204)	-0.310(0.069*)
Inefficiency variables			
Age	-0.007 (0.002) ***	0.002(0.343)	-0.118(0.072) *
Household size	0.395(0.400)	0.003(0.219)	0.002(0.176)
Formal education	0.004(0.000) ***	0.011(0.004) ***	0.001(0.002) ***
Poultry rearing experience	0.208(0.251)	-0.306(0.199)	0.005(0.095) *
Access to production credit	-0.009(0.062) *	-0.200(0.000) ***	-0.306(0.007)
Level of investment	-0.505 (0.005) ***	-0.118(0.004) ***	-0.301(0.000)
Diagnostic statistic			
Number of observation	78	115	193
Sigma-square (σ2)	0.541(0.002) ***	0.219(0.025) **	0.473 (0.005) ***
Gamma (γ)	0.289(0.054*)	0.054 (0.009) ***	0.233(0.001***)
Log likelihood function L/f	-103.07	-112.81	-109.00
LR test	42.00	45.00	57.09
Mean allocative efficiency	0.87	0.77	0.79

Asterisk indicate significance ***1%, **5%, *10%.

Table 5: The generalized LR test for the parameter of the inefficiency sources model

S/no	Quail rearing technique	LLF	χ^2 tab v:0.95 statistics	χ^2 calculated	Inferences
i	Battery cage system	-103.07	1.96	2.67	Accept
ii	Deep litter system	-112.81	2.01	3.02	Accept
iii	Pooled	-109.00	1.99	2.91	Accept

Note: LLF denote Log Likelihood Function, χ^2 implies Chi statistics; LR, likelihood ratio

The inefficiency sources model for BCS showed that the coefficients of age (-0.007), formal education (0.004), access to credit (-0.009) and investment (-0.505) are the significant socio-economic factors influencing efficiency. Similarly, formal education (0.011), access to production credit (-0.200) and level of investment (-0.118) contributed significantly to the explanation of efficiency in DLS production unit. The positive coefficients of level of education in BCS or DLS imply that a unit increase in education will lead to a corresponding increase in inefficiency in quail production. However, negative coefficients of credit utilized and investment in BCS and DLS quail technology suggest that a unit increase in these variables will increase efficiency of both quail production techniques.
Tables 4 and 5 showed that the null hypothesis, which specifies that inefficiency sources model does not have effects in the allocating resources in both BCS and DLS are accepted. In addition, δ_i values imply that the entire delta (δ_i) estimates are not zero. It further revealed that the delta variables estimated contributed significantly to the inefficiency of the quail farmers in the study area. It suffices to that the chi-square ($\varkappa^2$) calculated is greater than the $\varkappa^2$ tabulated in Table 5 indicating the relevance of the variables in both BCS and DLS production units respectively.

3.4 Relative allocative efficiency indices of quail production techniques

Table 6 shows the distribution of efficiency indices of quail farmers by techniques and pooled data. The battery-cage system minimum (19.85 %) and maximum (90.71 %) efficiency estimated were higher compared with DLS of 15.09 % and 82.72 % respectively. The mean allocative efficiency score of 76.4 % in BCS or 69.5 % in DLS implied that an average quail farmer sampled could thrive better in allocating resources by 23.6 % or 30.5 % to improve his allocative efficiency in quail production.

Further analysis indicates that more than half of BCS quail farmers (53.84 %) skewed towards efficiency level of 0.61-0.80. On the other hand, about half (48.7 %) of DLS quail farmers fell within efficiency range of 0.41-0.60. Thus, higher allocative efficiency of BCS may be connected with quail species habitat, which have the tendency to thrive better in their natural environment. In spite of this, the results implied that both rearing techniques operate at a relatively high allocative efficiency level and a considerable amount of output can be obtained by improving allocative efficiency in quail production in the two techniques.

Table 6: Allocative efficiency estimates of quail farmers for different rearing technology

	Battery cage (n = 78)		Deep litter (n = 115)		Pooled (n = 193)	
Class	F	%	F	%	F	%
0.21-0.40	4	5.13	21	18.26	23	11.92
0.41-0.60	18	23.08	56	48.7	79	40.93
0.61-0.80	42	53.84	30	26.09	69	35.75
0.81-1.00	14	17.95	8	6.95	22	11.40
Total	78	100	115	100	193	100
Mean	0.764		0.695		0.731	
Minimum	19.85		15.09		16.00	
Maximum	90.71		82.72		86.09	

3.5 Implications of profitability and the allocative efficiencies on farmers' output

The result implies that quail production is profitable in both rearing techniques. It could also be deduced that the allocative efficiencies of the sampled farmers is above the frontier. The demand-supply gap of poultry products could be bridged and sustainably increases its output using the available inputs and existing technology, if resources could be efficiently and optimally utilized as ample opportunity still exist to move closer to frontier as it was revealed in this study. The presence of inefficiency in quail poultry production system should also be addressed if quail poultry farmers intend to maximize their profit. Therefore poultry farmers' level of efficiencies could be increased if their specific factors such as level of investment, access to credit and formal education which are statistically significant factors influencing inefficiency, and in line with a priori expectations are adequately addressed.

4. Conclusion

Filtering the data of quail poultry production into battery cage and deep litter systems as well as pooled, this study conclude that the two systems exhibit different degrees of profitability and allocative efficiency in the two production systems. The allocative efficiency factors that influence battery cage system farmers showed variation from those influencing deep litter systems. However, where the same variable influenced both BCS and DLS, it is not by the same magnitude and direction. Therefore, it can be concluded that the battery cage system performed better with higher return to investment and better allocative efficiency.

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