Unizik Journal of Technology, Production and Mechanical Systems (UJTPMS)

journal homepage: https://journals.unizik.edu.ng/index.php/ujtpms/about
PRINT ISSN: 1115-7143 || ONLINE ISSN: 1115-7453

Economic analysis of poultry meat production process for maximum profitability: A case study approach

Emmanuel Okechukwu Chukwmuanya[1], Charles Chikwendu Okpala[2], Sunday Chimezie Anyaora[3*]

[1,2]Department of Industrial and Production Engineering, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria.

[3]Department of Mechanical Engineering, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria.

ARTICLE INFO

Article history:
Received May. 18, 2025
Revised June. 1, 2025
Accepted June. 8, 2025

Available online June 8, 2025

Keywords:
Poultry meat production, production strategies, profitability, return on investment, waste management.

ABSTRACT

The study investigates the optimization of poultry meat production strategies at X Farms Ltd, evaluating three production strategies: dressed chicken carcasses only, four chicken parts/sets only, and a mixed strategy. The research strategy employed is a combination of qualitative, quantitative, and mathematical models development methods. The results show that while the dressed chicken carcasses strategy yields the highest total profit (N527,515,639), the mixed strategy offers the highest return on unit investment (N3828/N1000). The study highlights the importance of considering factors such as waste management, profitability, and return on investment in choosing a production strategy. The findings suggest that farmers can optimize their production strategies and ensure sustainability of their business by prioritizing their resources and market conditions. Besides, by improving efficiency and reducing meat waste, farmers can increase profitability, enhance product quality, and reduce their environmental footprint. Moreso, application of economic analysis in poultry meat production can help poultry farms respond better to changing market conditions, consumer preferences, and environmental regulations. It can as well help poultry farms improve their overall performance.

1. Introduction

Poultry production has been a feature of human society for thousands of years (Robyn, 2019) and poultry industry, a significant contributor to global food production, provides a vital source of protein for human consumption. Using modern intensive farming techniques, global production has reached 133.4 million tons in 2020, with a steady growth each year (Goran *et al*, 2023). However, many poultry farms still rely on traditional practices and rules of the thumb in dealing with their daily business challenges, leading to suboptimal performance, waste, and inefficiencies. Poultry meat production is a complex process that involves multiple stages (Fig. 1 refers), from breeding and hatchery management to grow-out, processing, and distribution

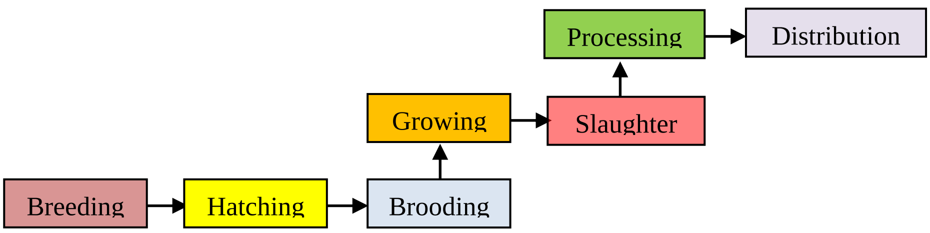


Figure 1: A flow chart of chicken meat production process

**Sunday Chimezie Anyaora: sc.anyaora@unizik.edu.ng*

which require careful planning, coordination, and control. Effective production and inventory management are critical to the success of poultry meat production, as they directly impact profitability, product quality, and environmental sustainability. They also ensure efficiency and sustainability in poultry farming.

In recent years, the poultry meat production industry has experienced significant changes, driven by factors such as globalization, technological advancements, and shifting consumer preferences. These changes have created new opportunities for producers to improve their operations, reduce costs, and increase efficiency. Despite these opportunities, many poultry meat producers continue to face significant challenges in optimizing their production processes. In response to these challenges, researchers and practitioners have begun to explore the potential of economic analysis and optimization techniques to improve decision-making in poultry meat production. These approaches offer a powerful tool for analyzing complex systems, identifying optimal solutions, and evaluating the economic and environmental implications of different production scenarios.

2. Literature Review

Poultry meat production is a significant contributor to the global meat industry, providing a vital source of protein for human consumption. The demand for poultry meat has been increasing steadily due to population growth, urbanization, their high quality, nutritional value, affordability and changes in dietary preferences (Godfray et al. 2010; Smith et al. 2015; Priyaranjan et al., 2020). Traditional poultry farms often use fixed supply quantities, leading to demand-supply imbalances and increased costs to balance requirements (Rajnish et al., 2022). According to the Food and Agriculture Organization (FAO), global poultry meat production is projected to continue growing, driven by increasing demand in developing countries.

Several studies have investigated poultry production and profitability. Wahyono and Utami (2018) reviewed Indonesia's poultry meat production industry, emphasizing food safety from farm to consumption. Godfray et al. (2016) used the Bat Algorithm to optimize poultry feed ration, finding significant economic benefits in including Moringa oleifera. Cara et al. (2024) reviewed broiler chicken welfare, identifying footpad dermatitis and lameness as key welfare indicators.

In Nigeria, Anosike et al. (2018) identified challenges in poultry production, including disease, lack of credit, and high feed costs. Proposed solutions include veterinary intervention and technical knowledge. Chukwumuanya et al. (2024) developed a Mixed-Integer Linear Programming (MILP) approach to optimize production planning, maximizing profit while minimizing waste.

Other relevant studies include works done by Priyaranjan *et al*. (2020) in using linear programming to minimize feed costs in small-scale poultry farms; Vinichenko *et al.* (2023) who applied economic and mathematical modeling to optimize agricultural production processes; Milena *et al.* (2024) that studied tetra SL hybrid hen technology and rearing for chicken welfare; and Mathias and Onabid (2018) that applied robust linear programming to maximize profit in poultry farming. Olalere *et al*. (2016) presented a multi-criteria proximal bundle-based optimization approach to chick-mash feed formulation.

These studies demonstrate the importance of optimizing production processes, managing costs, and prioritizing animal welfare to maximize profitability in poultry meat production

3. Materials and Methods

3.1 Materials

Materials and tools used in the study are: d*ata collection and text editing software* – Microsoft (MS) Excel Spreadsheet, MS Word application software, and internet search engine - Google search engine; and p*oultry farm data* on production levels, inventory levels, etc.) obtained from X Farms Limited, located in Anambra State of Nigeria which deals on production and sale of poultry eggs and broiler chicken meat.

3.2 Methods

The study employs a case study approach and use of economic analysis in evaluating the viability of poultry meat production business. This method involves an in-depth examination of a single poultry meat production firm – the X Farms Ltd. The case study approach is particularly suitable for this research because it allows for a detailed analysis of the firm's operations, decision-making processes, and responses to different scenarios. Research strategy employed is a combination of qualitative, quantitative, and mathematical models development methods. The qualitative methods involve a review of the literature, case study observations, and interviews with key personnel at the case study farm. The quantitative methods involve the collection and analysis of a two year numerical data on the farm's operations, including production costs, revenues, and outputs, while the mathematical modeling entails formulation of mathematical relationships that exist between parameters involved in meat production processes.

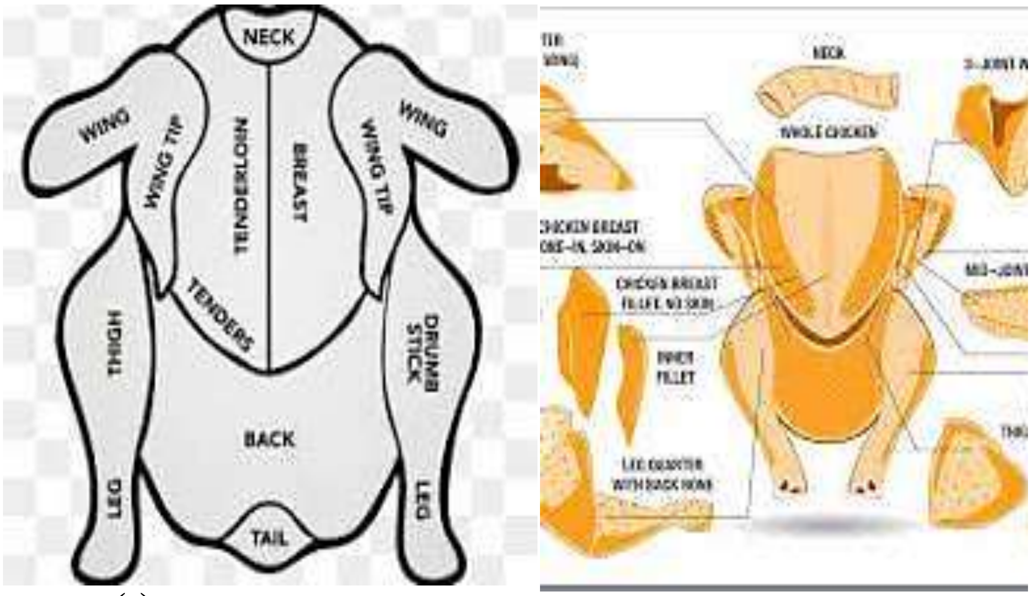
The collected data were extensively analyzed to identify and verify the trends, patterns, and correlations between variables. After, a number of mathematical models were developed, which were employed in conjunction with a number of economic analysis and statistical tools of the Excel spreadsheet to evaluate the economic aspect of the studied farm.

3.2.1 Identification and grouping of chicken body parts for ease of analysis

In poultry business, the chief raw materials for meat production are the young birds (chicks) procured and fed to maturity before slaughtering them for meat. Slaughtered chickens are usually processed and sold either in whole as eviscerated or dressed chicken carcasses, or in smaller parts. See Fig. 2

Assumptions:

- ✓ Meat waste is highly minimized: all parts of a slaughtered chicken are considered as meat; except the non-edible ones like the feathers, blood; bile; waste contents of the gilet, gizzard and intestines, etc.
- ✓ An eviscerated chicken carcass consisting of the parts shown in Figure (3b) and some other cut-outs not showing, are grouped and sold as 4 sets of products as follows:
  a. Breasts set: breasts and wings
  b. Thighs set: drumstick (thighs and legs) with the aile (ailette or leg quarter)
  c. Ribcage set: ribs, back, and tail
  d. Giblet set: gizzards, hearts, necks, liver, and head
- ✓ There are only three possible strategies in the poultry meat production: slaughtering and processing of all the chickens as eviscerated carcasses; slaughtering and processing of all the chickens as dressed carcasses; and slaughtering and processing of all the chickens into smaller body parts grouped into aforesaid four sets.



(a): Parts of a dressed chicken (b): Separate parts of a dressed chicken

Figure 2: Parts of a dressed chicken (ShutterStock, n.d.)

- ✓ The three production strategies are mutually exclusive.
- ✓ Choice of a production strategy to employ is flexible and determined by the market force of demand for its products.
- ✓ Quantity/nu of materials (number of chickens) to process in a chosen production strategy is dependent on the nature of demand for a product of interest of the strategy.
- ✓ The total fixed cost of production is shared equally among the individual items produced in a chosen strategy.
- ✓ Further processing an eviscerated carcass to a new meat product set attracts additional cost.
- ✓ Zero inventory – i.e. market demand $\geq$ quantity produced.

Other assumptions are presented in Table 1.

Table 1: Priori decision data for determining the optimal production strategy for profit maximization in chicken meat production business at the study site

Parameter	Definitions/Comments/Discussions	Value	Unit
x_{EC}	Ratio of contribution of an eviscerated or a dressed chicken carcass in the production process	1	unit
x_{Br}	Ratio of contribution of a chicken breasts set in the production process	0.30010	unit
x_{Th}	Ratio of contribution of a chicken thighs set in the production process	0.27480	unit
x_{RC}	Ratio of contribution of a chicken ribcages set in the production process	0.20000	unit
x_{GL}	Ratio of contribution of a chicken giblets set in the production process	0.22510	unit
C_{TFC}	Total fixed cost	10000000	N
k	Charge for processing a whole chicken, or each chicken part, unless where otherwise stated.	20	N
P	Profit	$\geq$ 20	%

3.2.2 Development of mathematical models for poultry meat production processes

I. ***Modeling of production quantity and chicken parts contributions in poultry meat production***

If there are *n* number of parts in an item, the sum of the individual weights of the parts defines the weight (w_i) of the item. This can be defined mathematically as follows:

$$w_i = w_1 + w_2 + w_3 + ... + w_n \quad (1)$$

Adding more to above assumptions, 1 eviscerated chicken carcass consists of 2 breasts part/set, 2 thighs part/set, 1 ribcage set/part and 1 giblet part/set. This implies that the weight of an eviscerated chicken carcass (w_{EC}) is defined thus:

$$w_{EC} = 2w_{Br} + 2w_{Th} + w_{RC} + w_{GL} \quad (2)$$

Where,

w_{Br} = weight of the breasts set
w_{Th} = weight of the thighs set
w_{RC} = weight of the ribcage set
w_{GL} = weight of the giblet set

And for a dressed chicken carcass (Fig. 4a) consisting of 2 breasts part/set, 2 thighs part/set, and 1 giblet set/part, its weight (w_{DC}) is obtained from the relation:

$$w_{DC} = 2w_{Br} + 2w_{Th} + w_{GL} \quad (3)$$

Joining eqn. (2) and eqn. (3) and rearranging the expression gives,

$$w_{EC} = w_{DC} + w_{GL} \quad (4)$$

Compare eqns (1) and (4)

So, for a poultry bird having various number of its components parts 1, 2, 3, …, *n*, the total weight equation can be mathematically expressed thus:

$$w = aw_1 + bw_2 + cw_3 + ... + w_n \quad (5a)$$

To establish a relation for obtaining the total weight (w_T) of a given number of chicken carcasses say, X_m, having a mean chicken parts weight, *w*, we write:

$$w_T = w\,X_m \quad (5b)$$

Again, considering the maximum quantity (number) of new stock of raw materials (chicks) procured by and the production capacity of a given poultry farm in a production cycle, the following mathematical expression subsists:

$$X_T = X_L + X_m \quad (6)$$

Where

X_T = the production capacity/total number of new stock (day-old chicks) of raw materials
X_L = the number of chicks lost due to mortality or mishap
X_m = the number of chicks raised to maturity and used in meat production.

Following the same reasoning as in eqns. (1) to (5b), ***x*** number of eviscerated chicken carcasses will consist of ***x*** number of dressed chicken carcass sets and ***x*** number of giblets sets. This assumption is written mathematically as:

$$x_{EC} = x_{DC} + x_{GL} \quad (7a)$$

Also a dressed chicken carcass is assumed to consist of 2 breasts set, 2 thighs set, 1 ribcages set, and 1 giblets set part. This consideration enables eqn. (2a) to be rewritten as:

$$x_{EC} = 2x_{Br} + 2x_{Th} + x_{RC} + x_{GL} \quad (7b)$$

Joining eqn. (7a) and eqn. (7b) and rearranging the expression gives,

$$x_{DC} = 2x_{Br} + 2x_{Th} + x_{RC} \quad (8)$$

Consequently, the total number of chickens slaughtered for meat production (X_m) in a cycle is the sum of the chicken parts contained in eqns. (7a), (7b), and/or (8):

$$\Sigma x_{EC} = \Sigma x_{DC} + \Sigma x_{GL} \quad (9a)$$

Or $$X_{EC} = 2\Sigma x_{Br} + 2\Sigma x_{Th} + \Sigma x_{RC} + \Sigma x_{GL} \quad (9b)$$

And generally, $$X_m = X_{EC} = ax_1 + bx_2 + cx_3 + \dots + zx_n \quad (9c)$$

Where, the coefficients a, b, c, …, *z* are the numbers *of the various parts/sets in a chicken/bird*; and the maximum quantity of each of the parts/sets that be produced in production cycle is:

$$\left.\begin{array}{ll} X_{EC} = X_m & (i) \\ X_{DC} = X_m & (ii) \\ X_1 = aX_m & (iii) \\ X_2 = bX_m & (iv) \\ X_3 = cX_m & (v) \\ \cdot \quad \cdot \quad \cdot & \\ \cdot \quad \cdot \quad \cdot & \\ x_n = zX_m & (n+2) \end{array}\right\} \qquad (9d)$$

So, the maximum production quantity in a given cycle is limited by the quantities in eqn. (9d), and can be defined by the relation:

$$Q_m = \Sigma X_{EC} = \Sigma(ax_1 + bx_2 + cx_3 + \ldots + zx_n) \qquad (10)$$

II. Modeling of the total costs, total revenue, selling price, and profit in poultry meat production

In production, many costs considerations are made, among which are fixed, variable, and semi-variable costs. In this study, some of these costs have been lumped together and referred to as total fixed cost (C_{TFC}). The C_{TFC} include costs of labor, materials, administrative expenses, overhead, equipment maintenance, salaries, environmental impact, electricity bills, etc.

Consequently, the total in-process/variable production cost (C_{TV}) of an eviscerated chicken carcass is defined in the study as:

$$C_{TV} = \frac{\alpha X_T + \beta X_L + \varphi X_m}{X_m} + k \qquad (11a)$$

And the total variable production cost per unit weight, $C_{TV/kg}$, of an eviscerated chicken carcass in a given cycle is also defined by the relation:

$$C_{TV/kg} = \frac{C_V X_m}{w} = \left(\frac{\alpha X_T + \beta X_L + (\varphi + k)\, X_m}{w}\right) \qquad (11b)$$

Where,

k = additional processing cost for a chicken part set per cycle
α = unit cost of a day old chick
β = mean cost (e.g. costs of feeding, medication, etc.) of attending to birds that died before maturity/slaughter age
φ = Mean cost of attending to full grown birds, from day-old to slaughter age, in a given cycle

The total production cost (C_{TC}) or the total expenditure (E_T) made in meat production per given time can be calculated from a combination of eqn. (8b) and C_{TF} as:

$$C_{TC} = E_T = C_{TV} + C_{TF} \qquad (12a)$$

The actual unit cost in weight measure ($C_{AP/kg}$) of eviscerated chicken carcass produced per given period is given by the relation:

$$C_{AP/kg} = \frac{C_{AP}}{w} = \frac{C_{TC}}{wX_m} \qquad (12b)$$

If P is the total profit desired in a given cycle and is expressed as a fraction (f) of the total expenditure, then:

$$P = f\,E_T \qquad (13)$$

The expected total revenue (R_T) from the sale of the chicken parts to cover the overall expenses and profit can be calculated from the relation:

$$R_T = (1 + f)E_T \qquad (14)$$

Therefore the mean unit selling price (S_p) of the chicken parts to earn P can be calculated from the relation:

$$S_P = \frac{R_T}{X_m} \qquad (15a)$$

Or in terms of chicken part per kg:

$$S_{P/kg} = \frac{R_T}{wX_m} \qquad (15b)$$

III. Modeling for the economic analysis of the meat production process

Meanwhile, some popular economic analysis approaches in operations research (OR) include: cost-benefit analysis (CBA), return on investment (ROI), cost-effectiveness analysis (CEA), break-even analysis (BEA), comparative cost analysis (CCA), discounted cash flow analysis (DCFA), and Sensitivity Analysis (SA). SA is used to test the robustness of the optimal alternative to changes in assumptions. Tools used in conducting economic analysis include: Spreadsheets (e.g. Microsoft Excel, Google Sheets), Economic modeling software (e.g. GAMS, MATLAB), and Decision support systems (e.g. Expert systems, optimization software).

Figure 3 depicts the steps followed in conducting economic analysis in the study which are clearly

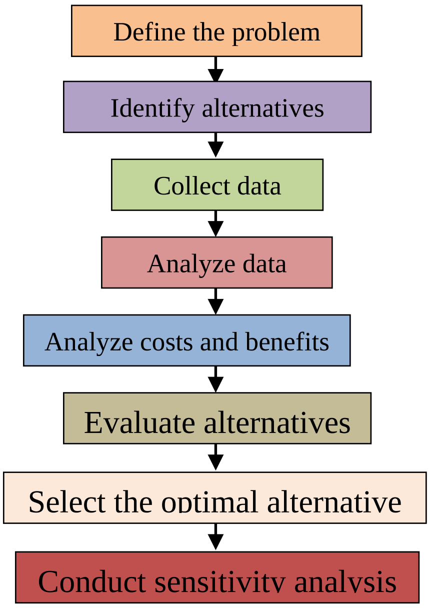


Figure 3: Algorithm for conducting economic analysis on the poultry meat production

articulating the problem to be addressed; determining the possible courses of action; gathering relevant data on costs, benefits, and other economic factors; calculating and categorizing costs (fixed, variable, direct, indirect); calculating and categorizing benefits (revenue, savings, externalities); comparing the costs and benefits of each alternative; choosing the alternative with the highest net benefit; and conducting sensitivity analysis to test the robustness of the optimal alternative to changes in assumptions made.

Economic analysis tools employed in this study are CCBA and ROI.

Return on Investment (ROI) formula used in the study is based on total profit made per total amount invested in production and is defined thus:

$$\text{ROI} = \frac{P_{\text{Net}} \text{ x } 100}{E_T} \quad (16)$$

By applying economic analysis, decision-makers are guided to make informed choices that maximize economic efficiency and achieve their objectives.

3.2.4 A case study on poultry meat production and sales strategies

Presently, X Farms Ltd. operates two business lines: egg production and sales, and broiler chicken meat production and sales. The farm sells slaughtered broiler chickens as dressed chicken carcasses. Market surveys conducted in the course of this study indicate that there is a greater demand for smaller parts of the chicken (breasts, thighs, gizzards, ribcages, and giblets) than dressed carcasses as meat. Following these revelations, three case study problems were investigated for solutions in line with the desires of the objectives of this study.

Case study problem statement

X Farms Ltd aims to maximize profits from its broiler chicken meat production and sales. Given the company's production capacity, costs, and market conditions, it is required that the optimal sales strategy be determined.

Given parameters: As contained in Table 2, and Table 3.

Table 2: Fixed cost items at X Farms Ltd., Anambra State, Nigeria

Fixed Production Item	Value	Unit
One cycle	6	weeks
Slaughtering duration per Cycle	14	days
Production lines	2	-
Storage capacity per cycle	7500	kg

Minimum inventory level	2000	kg
Lumped fixed cost per month	10m	₦
Storage cost per kg chicken part per month	500	₦
Additional processing cost per chicken part/set	20	₦

Production Strategies:

From the eighteen months production period, evaluate the following three production strategies:

1. Continue in its present strategy of production and sale of the whole products as dressed chicken carcasses.
2. Produce and sell the whole chicken products in four separate parts (breasts set, thighs set, ribcages set, giblets set)
3. Adopt a mixed strategy: Production of the chickens and selling some as dressed chicken carcasses and others in four smaller parts – breasts sets, thighs sets, ribcages sets, and giblets sets?

Requirements:

For each production strategy:
1. Calculate actual unit and total production costs of each chicken part
2. Determine unit selling price of each chicken part for a 20% profit
3. Evaluate the profit earnings.
4. Conduct economic analysis on the meat production system to determine the optimal sales strategy (whole, parts, or mixed) to maximize profits
5. Conduct sensitivity analyses to assess the impact of changes in key variables
6. Discuss managerial implications of the results

Table 3: Summary of chicken meat production data at the X Farms Ltd., Anambra State from January 2022 to January 2024

No. of Runs (Cycles)	Production Time (6 Weeks)	New Stock/ Arrivals (day old chicks)	Unit Cost of Day Old Chick (N)	Mean Weight per Day Old Chick (g)	Number Lost/Dead During Processing Period	Number Processed to Slaughter/ Sales	Mean Production Cost per dressed Chicken (N)	Mean Weight per cycle (kg)			Quantity of Feed Consumed (bags)	Quantity Demanded per cycle (units)
								Live Chicken	Evisce-rated Chicken	Dressed Chickens		
1	Jan - Feb	25500	300	42	1060	24440	2000	2.25	1.575	1.350	4305	25391
2	Feb - Mar	25500	300	41	1640	23860	2100	2.20	1.540	1.320	4215	24120
3	Mar- May	25500	350	43	1540	23960	2300	2.40	1.680	1.440	3980	21882
4	May - Jun	25500	350	40	1190	24310	2300	2.15	1.505	1.290	4005	24681
5	Jun - Jul	25500	350	41	1234	24266	2600	2.20	1.540	1.320	4290	23822
6	Jul - Sep	25500	375	42	1835	23665	2700	2.30	1.610	1.380	4164	23673
7	Sep - Oct	25500	375	40	1196	24304	2700	2.18	1.526	1.308	4203	24668
8	Oct - Dec	25500	450	42.5	2790	22710	2900	2.35	1.645	1.410	3764	26442
9	Dec - Jan	25500	450	41	1364	24136	2900	2.20	1.540	1.320	4068	24548
10	Jan - Feb	25500	450	41	1347	24153	3000	2.20	1.540	1.320	3974	22267
11	Feb - Apr	25500	450	42	1135	24365	3000	2.32	1.624	1.392	3700	23190
12	Apr - May	25500	475	40	1230	24270	3100	2.18	1.526	1.308	3580	26250
13	May - Jun	25500	475	40	1340	24160	3200	2.20	1.540	1.320	4160	22007
14	Jun - Aug	25500	550	41	1436	24064	3300	2.20	1.540	1.320	4132	25598
15	Aug- Sep	25500	550	42	1533	23967	3300	2.33	1.631	1.398	3994	21687
16	Sep - Nov	25500	600	42	1940	23560	3500	2.35	1.645	1.410	4179	22071
17	Nov - Dec	25500	600	40	1210	24290	3500	2.20	1.540	1.320	4302	26896
18	Dec - Jan	25500	650	41	1486	24014	3500	2.21	1.547	1.326	3859	23891
	Mean =	**25500**	**450**	**41**	**1473**	**24027**	**2883**	**2.25**	**1.572**	**1.347**	**4048.6**	**24060**

4. Results and Discussion

Table 4 is structured to contain all the results of the analysis done for each of the production cycles using the mathematical models developed in the study. It clearly shows the mean and total values of the various vital parameters considered in the stated three poultry meat production strategies. The data include the costs of production, revenues, selling prices, and the accruing profits for the main meat products and for the pieces of meat produced as by-products in the production process which are regarded as wastes at the X Farms Ltd.

Table 4 shows how the values for the parameter indicated in all the 18 production cycles of the study were determined. In the first production cycle ($\boldsymbol{r}$ = 1) of the table, a 6 weeks period starting from January 1 and ending in February, 2022, the total number of broiler chickens slaughtered for dressed carcasses production is 24440. The mean weights of the eviscerated and dressed chicken carcasses are $(\boldsymbol{w}_{T})_{EC}$ = 1.5749 kg and , $(\boldsymbol{w}_{T})_{EC}$ = 1.35 kg respectively. For Production Strategy 1, at $\boldsymbol{k}$ = ₦0/carcass the mean values of other parameters are the same: mean variable cost of production ($\boldsymbol{C}_{TV}$) = ₦2000.35, mean total cost of production ($\boldsymbol{C}_{TC}$) = ₦2409.52, the mean revenue at 20% of the production cost as profit, ($\boldsymbol{R}_{T}$) = ₦2650.47, the mean unit selling price $(\boldsymbol{S}_{p})_{20\%}$ = ₦2650.47 (or ₦1835.94/kg), and mean profit $(\boldsymbol{P}_{T})_{20\%}$ = ₦240.95. The mean weight of parts cut out from each eviscerated chicken carcass in processing the later to obtain a dressed chicken carcass = 0.22 kg. Selling a total of this quantity of waste at ₦1835.94/kg for the 24440 dressed chicken carcasses, the revenue returned to the farm as profit (P_T) ≈ ₦10091335. The waste meat details are placed at the lower portions of each cycle bounded with broken lines.

Table 4: **Results of the analysis made with the production data from X Farms Ltd., Anambra State at *k* = ₦0/ eviscerated carcass and *k* = N20/other meat products using the developed mathematical model**

r (Cyc)	t (6 Wks)	Production Strategy	Chicken Part	*Sum*	w (kg) Eqn. (2)	x_m (units) Table 1	C_{TV} (₦) Eqn. (11a)	$C_{(TFC)}$ (N)	k (₦)	C_{TC} (₦) Eqn. (12b)	(R_T) (₦) Eqn. (14)	$(S_P)_{Br20\%}$ (₦) Eqn. (15a)	$(S_P)_{20\%/kg}$ (₦) Eqn. (15b)	$(P_T)_{20\%}$ (₦) Eqn. (13)
					Parts Mean Contributions to a Whole Eviscerated Chicken Body Data per Production Cycle									
1	Jan - Feb	1	**Eviscerated Carcasses**	Mean =	1.5749	1	2000.35	409.17	0	2409.52	2891.42	2891.42	1835.94	481.90
				Total =	**38490.56**	**24440**	**48888554**	**10000000**	**0**	**58888554**	**70666265**	**2891**	**70666265**	**11777711**
			Dressed Carcasses (whole)	Mean =	1.35	1	2000.35	409.17	0	2409.52	2891.42	2891.42	1835.94	481.90
				Total =	**32994.00**	**24440**	**48888554**	**10000000**	**0**	**58888554**	**70666265**	**2891.42**	**70666265**	**11777711**
			Waste Meat	**Mean =**	**0.22**	**1**	**0**	**0**	**0**	**0**	**413**	**0**	**412.90**	**412.90**
				Total =	**5496.56**	**24440**	**0**	**0**	**0**	**0**	**10091335**	**0**	**10091335**	**10091335**
		2	Breasts Set	Mean =	0.4726	0.30010	600.31	122.79	20	743.10	891.71	891.71	566.20	148.62
			Thighs Set		0.4328	0.27480	549.70	112.44	20	682.13	818.56	818.56	519.75	136.43
			Ribcages Set		0.3150	0.20000	400.07	81.83	20	501.90	602.28	602.28	382.43	100.38
			Giblets Set		0.3545	0.22510	450.28	92.10	20	562.38	674.86	674.86	428.51	112.48
			Eviscerated Carcasses		**1.5749**	**1**	**2000.35**	**409.17**	**80**	**2489.52**	**2987.42**	**2987.42**	**1896.89**	**497.90**
			Breasts Set	Totals =	11551.02	7334	14671455	3001000	488800	18161255	21793506	891.71	566.20	3632251
			Thighs Set		10577.20	6716	13434575	2748000	488800	16671374	20005650	818.56	519.75	3334275
			Ribcages Set		7698.11	4888	9777711	2000000	488800	12266510	14719813	602.28	382.43	2453302
			Giblets Set		8664.22	5501	11004814	2251000	488800	13744613	16493536	674.86	428.51	2748923
			Eviscerated Carcasses		**38490.56**	**24440**	**48888554**	**10000000**	**488800**	**60843754**	**73012505**	**2987.42**	**1896.89**	**12168751**
		3	**Eviscerated Carcasses**	Mean =	1.5749	1	2000.35	409.17	0	2409.52	2891.42	2891.42	1835.94	481.90
			Dressed Carcasses (whole)	Mean =	1.35	1	2000.35	409.17	20	2429.52	2915.42	2672.47	1979.61	485.90
				Total =	**16497.00**	**12220**	**24444277**	**5000000**	**244400**	**29688677**	**35626412**	**2672.47**	**1979.61**	**5937735**
			Waste to Wealth	**Mean =**	**0.225**	**1**	**0**	**0**	**0**	**0**	**0**	**0.00**	**445.21**	**445.21**
				Total =	**2748.28**	**12220**	**0**	**0**	**0**	**0**	**5440505**	**0.00**	**5440505**	**5440505**
			Breasts Set	Mean =	0.4726	0.30010	600.31	122.79	20	743.10	891.71	817.41	566.20	148.62
			Thighs Set		0.4328	0.27480	549.70	112.44	20	682.13	818.56	750.35	519.75	136.43
			Ribcages Set		0.3150	0.20000	400.07	81.83	20	501.90	602.28	552.09	382.43	100.38
			Giblets Set		0.3545	0.22510	450.28	92.10	20	562.38	674.86	618.62	428.51	112.48
			Eviscerated Carcasses		**1.5749**	**1**	**2000.35**	409.17	**80**	**2489.52**	**2987.42**	**2738.47**	**1896.89**	**497.90**
			Breasts Set	Totals =	5775.51	3667	7335728	1500500.00	244400	9080627	10896753.03	891.71	566.20	1816126
			Thighs Set		5288.60	3358	6717287	1374000.00	244400	8335687	10002824.78	818.56	519.75	1667137
			Ribcages Set		3849.06	2444	4888855	1000000.00	244400	6133255	7359906.48	602.28	382.43	1226651
			Giblets Set		4332.11	2751	5502407	1125500.00	244400	6872307	8246768.10	674.86	428.51	1374461
			Eviscerated Carcasses		**19245.28**	**12220**	**24444277**	**5000000**	**977600**	**30421877**	**36506252.40**	**2987.42**	**1896.89**	**6084375**
			Dressed Carcasses + Smaller Parts + Waste	**Total =**	**38490.556**	**24440**	**2000.35**	**10000000**	**1222000**	**60110554**	**77573170**	**-**	**-**	**17462616**

Again in $\boldsymbol{r}$ = 1, Production Strategies 2 and 3 (the mixed strategy), the same 24440 eviscerated broiler carcasses of mean weight, w_{EC} = 1.5749 kg were slaughtered. In strategy 2, they were processed into four sets of meat products: breasts, thighs, ribcages, and giblets sets. In strategy 3, 12220 of thecarcasses were processed into dressed carcasses, while the remaining 12220 carcasses were processed into four smaller parts as in strategy 2. The mean and total costs of production and revenues realized, including the selling prices, and profits from the sale of each of the sets of products were also determined and recorded as depicted in Table 4. No meat waste was generated in strategy 2. Following these same explanations, values for the same parameters in the other production cycles ($\boldsymbol{r}$ = 2 to $\boldsymbol{r}$ = 18) should be easily be understood.

Table 5: **Summary of the production costs and generated revenues in the three poultry meat production strategies**

r Cycle	**Production Strategy 1**				**Production Strategy 2**				**Production Strategy 3**			
	Total Production Cost (₦)	**Revenue from Main Sales (₦)**	**Profit from Main Sales (₦)**	**Revenue from Waste Sales (₦)**	**Total Production Cost (₦)**	**Revenue from Main Sales (₦)**	**Profit from Main Sales (₦)**	**Revenue from Waste Sales (₦)**	**Total Production Cost (₦)**	**Revenue from Main Sales (₦)**	**Profit from Main Sales (₦)**	**Revenue from Waste Sales (₦)**
1	58888554	70666265	11777711	10091335	60843754	73012505	12168751	0	29688677	35626412	5937735	5440505
2	60117691	72141230	12023538	10305890	62026491	74431790	12405298	0	30297446	36356935	6059489	5554532
3	65106083	78127300	13021217	11161043	67022883	80427460	13404577	0	32792642	39351170	6558528	6011984
4	65913729	79096475	13182746	11299496	67858529	81430235	13571706	0	33199965	39839958	6639993	6086660
5	73088688	87706426	14617738	12529489	75029968	90035962	15005994	0	36787004	44144405	7357401	6744284
6	73891477	88669772	14778295	12667110	75784677	90941612	15156935	0	37182388	44618866	7436478	6816771
7	75629792	90755751	15125958	12846161	77574112	93088935	15514822	0	38057936	45669523	7611587	6902722
8	75849235	91019082	15169847	13002726	77666035	93199242	15533207	0	38151717	45782061	7630343	6994482
9	79996331	95995597	15999266	13713657	81927211	98312653	16385442	0	40239525	48287431	8047905	7377246

10	82451030	98941235	16490206	14134462	84383270	101259923	16876654	0	41467045	49760454	8293409	7602292
11	83086960	99704351	16617392	14366267	85036160	102043391	17007232	0	41787130	50144556	8357426	7738135
12	85240398	102288477	17048080	14478579	42518080	51021696	8503616	0	42862899	51435479	8572580	7774217
13	82472027	98966433	16494405	14138062	87181998	104618397	17436400	0	41477614	49773136	8295523	7604229
14	89406147	107287376	17881229	15326768	84404827	101285793	16880965	0	44943713	53932456	8988743	8239681
15	89081034	106897241	17816207	15139953	91331267	109597520	18266253	0	44780187	53736224	8956037	8127604
16	92451518	110941822	18490304	15848832	90998394	109198073	18199679	0	46461359	55753631	9292272	8517916
17	95011842	114014211	19002368	16287744	94336318	113203582	18867264	0	47748821	57298585	9549764	8753951
18	94051401	112861682	18810280	15831277	96955042	116346051	19391008	0	47265841	56719009	9453168	8482975
Overall =	**1421733938**	**1706080725**	**284346788**	**243168851**	**1402879016**	**1683454819**	**280575803**	**0**	**715191909**	**858230291**	**143038382**	**130770185**

Table 5 depicts a summary of the overall results of the analysis done in Table 4 for the entire 18 cycles of the 2 years production period. It shows for the three production strategies, the total production costs, total revenues from main products, the total profits made, and the total realizable revenues from the sale of parts of the poultry meat regarded as waste at X Farms Ltd.

Figures 4 to 9 make understanding of the discussions on Table 4 clearer. The figures are plots of data from Table 4 for the three production strategies in the entire production period showing the overall production costs, the overall revenue realized from sale of the main products and the amount realized from sale of parts of the chicken carcasses regarded as wastes in the study farm as profits. The figures are self-explanatory. The "wastes" are pieces of meat produced as "by-products" in production of dressed chicken carcasses of production strategies 1 and 3.

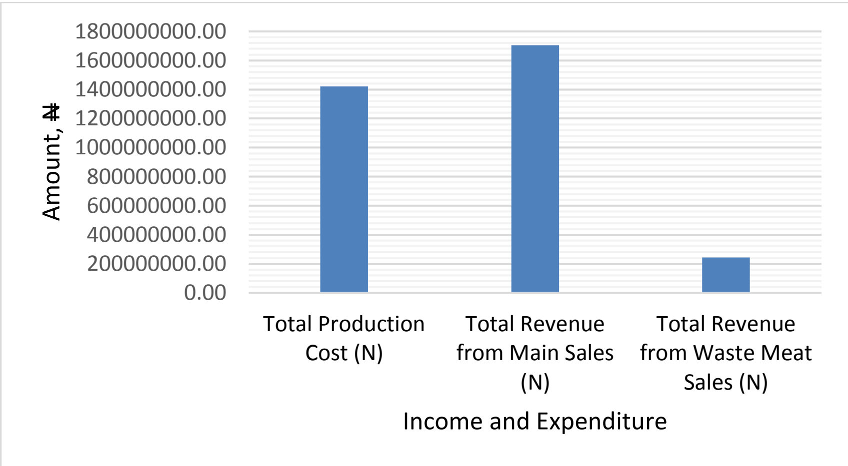


Figure 4: Plot of the overall production cost and total amounts generated as revenues in Production Strategy 1

In Figure 4, the total/overall production cost is ₦1421733938, the total revenue returned from sale of the main meat products is ₦1706080725, and the total revenue from sale of waste meat is ₦243168851. See Fig. 5.

Fig. 5 is a chart showing the total revenue returned after sales to the farm in Production Strategy 1. From the total revenue, the total profit made in Production Strategy 1, is ₦(1706080725 – 1421733938) + ₦243168851 = ₦527515638.51; which represents ≈ 27% of the total amount, while rest (≈ 73%) represents the total amount of money spent as cost in production.

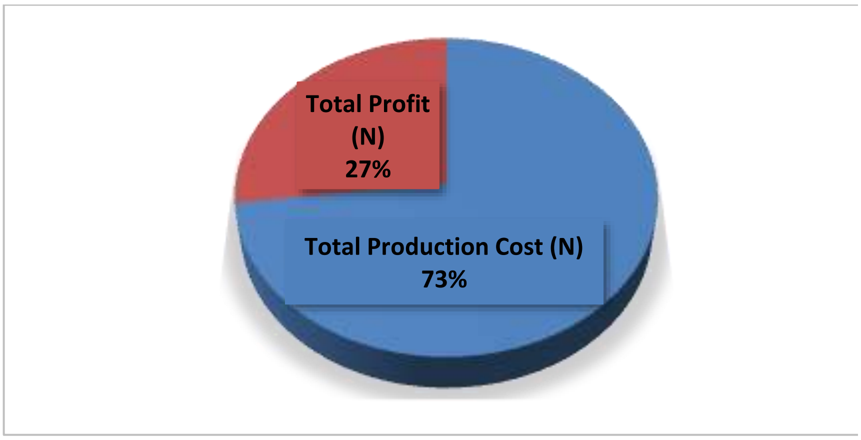


Figure 5: Contributions of the overall production cost and total profit in the total revenue of Production Strategy 1

Fig. 6 clearly shows that there are zero waste meat parts generation in Production Strategy 2; all the edible parts of the slaughtered chicken carcasses belong to any of the four meat product sets. Hence, no money was realized from sale of waste meat as income. The total cost of production is ₦1402879016.96, and the total revenue generated is ₦1683454819.13.

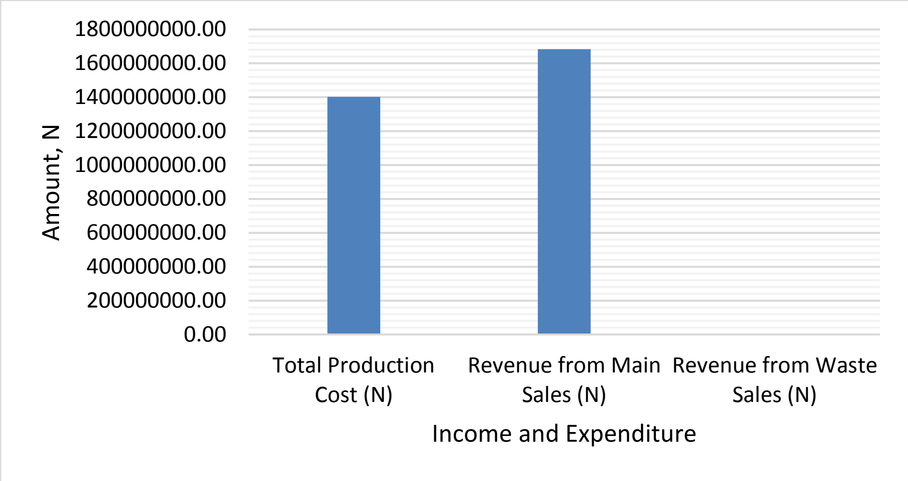


Figure 6: Plot of the overall production cost and total amounts generated as revenues in Production Strategy 2

Fig. 7 is a sister chart of Fig. 5 for Production Strategy 2. Here, the total production cost of the meat products is ≈ 83% of the total revenue, and the total profit is ≈ 17%.

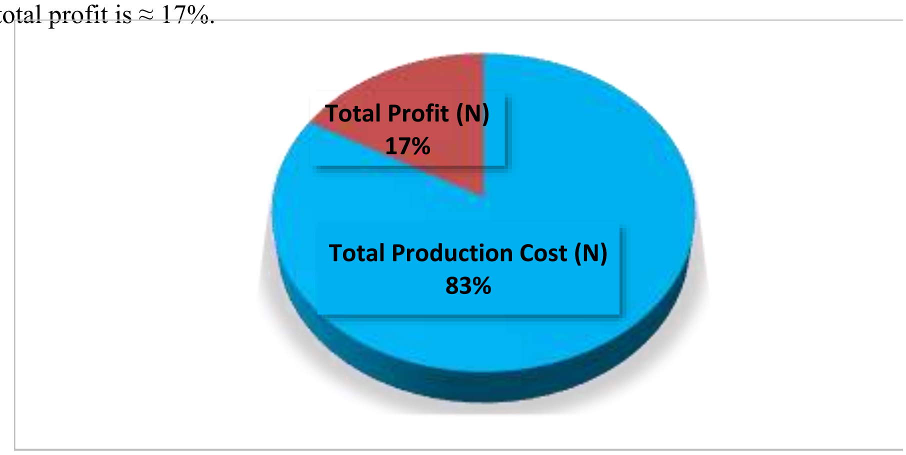


Figure 7: Contributions of the overall production cost and total profit in the total revenue of Production Strategy 2

Data on Production Strategy 3 were used in plotting Fig. 8 which shows the total production cost as ₦715191909, the total revenue returned from sale of the main meat products as ₦858230291, and the total revenue from sale of waste meat as ₦130770185.

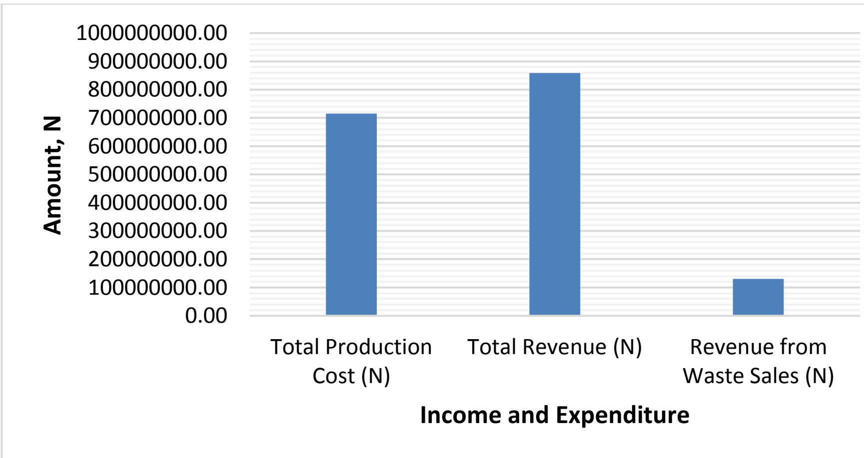


Figure 8: Plot of the overall production cost and total amounts generated as revenues in Production Strategy 3

Fig. 9 is a chart on Production Strategy 3, showing the production cost of the meat products as 72% of the total revenue, and the total profit as 28%.

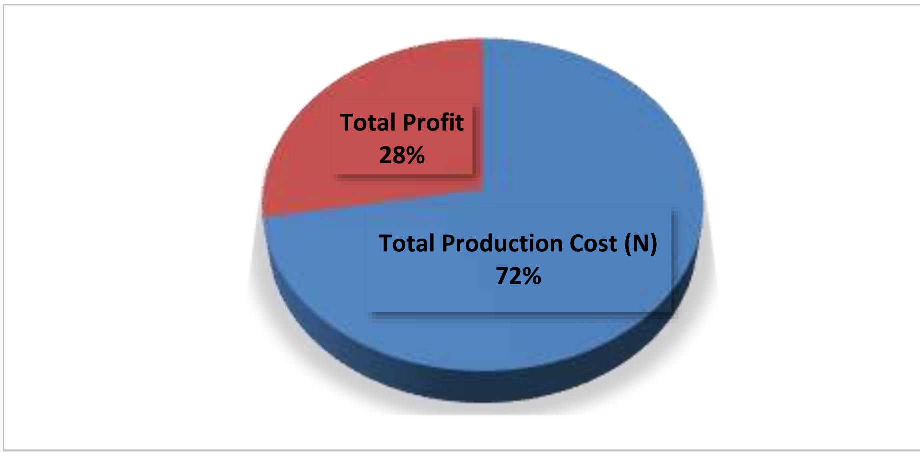


Figure 9: Contributions of the overall production cost and total profit in the total revenue of Production Strategy 3

4.2 Comparative Cost-Benefit Analysis of the Three Poultry Meat Production Strategies

From a combined view of various authors in literature, economic analysis is portrayed as a systematic approach to understanding the economic aspects of a decision, project, or business. It involves examining the costs and benefits of different alternatives to determine the most economically viable option.

Table 10 holds the sums of the total production costs, the total profits, and the ratios of the total profits made to the total cost of production. A quick look at the table without due considerations could lead to false conclusions. This is because, just focusing at the profits made in the table shows that Production Strategy 1 has the highest profit margin (₦527515638.51), followed by Production Strategy 2 (₦280575803.19), with the mixed production strategy having the lowest profit yield. However, considering the profit made on unit cost of production (returns on unit investments, ROUI) in each of the three strategies, it will be seen that Production Strategy 3 yields more profit (₦3828/₦1000) than the other two strategies: Strategy 1 (₦3710/₦1000), and Strategy 1 (₦2000/₦1000)

Table 6: Comparative analysis of the three poultry meat production strategies for maximum profitability

Production Strategy	Total Production Cost (₦)	Total Profit (₦)	Profit per Unit Cost (₦/₦)
1: Dressed Chicken Carcasses only	1421733937.57	527515638.51	0.3710
2: Four Chicken Parts/Sets only	1402879015.95	280575803.19	0.2000
3: Dressed Chicken Carcasses + Four Chicken Parts/Sets	715191908.79	273808566.42	0.3828

For visual appreciation of the foregoing explanation, the results of profit per unit cost of production analysis on the three production strategies in Table 5 are plotted as in Fig. 10. The figure speaks for itself.

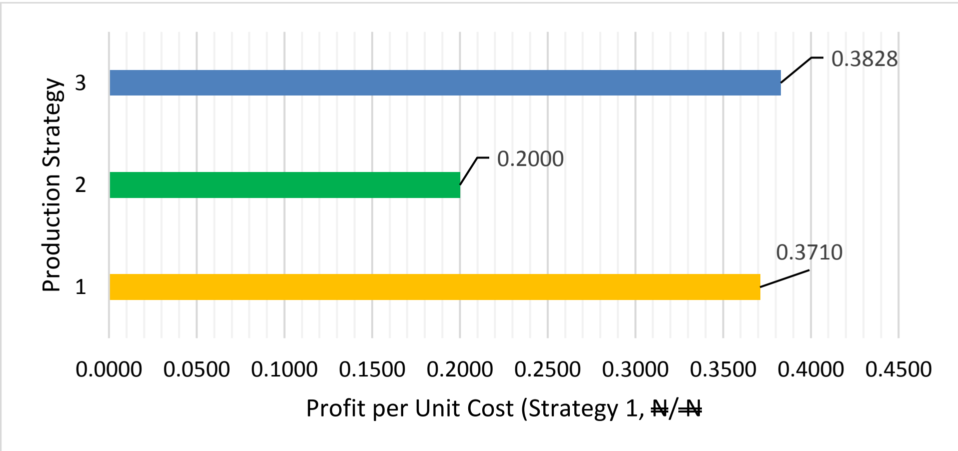


Figure 10: Comparative analysis of the three poultry meat production strategies for maximum returns

5. Conclusion

This study employs a case study approach in applying mathematical modeling and economic analysis to evaluate the viability of poultry meat production systems. This method involves an in-depth examination of a single poultry meat production firm – the X Farms Ltd. located in Anambra State of Nigeria. The case study approach is particularly suitable for this research because it allows for a detailed analysis of the firm's operations, decision-making processes, and responses to different scenarios.

Results from the analysis made show that if Farm X produced and sold only dressed chicken carcasses (Production Strategy 1) as poultry meat products in the study period, it would make the highest profit margin of ₦527515638.51; or where it produced the meat products in smaller parts (Production Strategy 2), it would make a total profit of ₦280575803.19; and adopting the mixed production strategy would give the lowest overall profit yield. However, considering the profit made on unit cost of production (returns on unit investments, ROUI) in each of the three strategies, it will be seen that Production Strategy 3 yields more profit (₦3828/₦1000) than the other two strategies: Strategy 1 (₦3710/₦1000), and Strategy 1 (₦2000/₦1000). From these revelations, it is recommended that Farm X should continue in its present production strategy and should start selling the parts of the chicken carcasses it treats as waste as meat product sets as already discussed in the study. To allow for flexibility in choice of its products which would enable it make more ROUI, the farm may consider the mixed production strategy as a second option. Production and sale of the chicken carcasses in smaller parts should be left for the retailers that sell directly to final consumers.

From the foregoing, therefore, Farm X can increase its profitability, enhance product quality, and reduce their environmental footprint by improving efficiency and reducing meat waste. Moreover, application of economic analysis in poultry meat production can help poultry farms respond better to changing market conditions, consumer preferences, and environmental regulations. It can as well help poultry farms improve their overall performance.

Bibliography

[1] Ajuwa, H. A., Elenwa, C.O. and Isife, B. I. (2024). Adoption of Poultry Farming Technologies for Increased Poultry Production in Yenagoa Local Government Area, Bayelsa state. International Journal of Agriculture and Earth Science (IJAES) E-ISSN 2489-0081 P-ISSN 2695-1894 Vol 10. No. 5 2024 www.iiardjournals.org DOI: 10.56201/ijaes.v10.no5.2024.pg248.257

[2] Anosike F. U., Rekwot G. Z., Owoshagba O. B., Ahmed S. and Atiku J. A. (2018). Challenges of poultry production in Nigeria: A review. Nigerian Journal of Animal Production. Vol. 45(1): 252 – 258.

[3] Cara Helena Wilcox, Victoria Sandilands, Novi Mayasari, Indrawati Yudha Asmara & Asep Anang (2024) A literature review of broiler chicken welfare, husbandry, and assessment, World's Poultry Science Journal, 80:1, 3-32, DOI: 10.1080/00439339.2023.2264824 To link to this article: https://doi.org/10.1080/00439339.2023.2264824

[4] Chukwumuanya Emmanuel Okechukwu, Uchendu Somtochukwu Emmanuel, Okpala Charles Chikwendu, Dara Jude Ezechi (2024). Optimization of Poultry Farm Production Planning for Maximum Returns Using Mixed-Integer Linear Programming Approach. International Journal of Industrial and Production Engineering (IJIPE). Vol.2 No.3 (2024), pg. 1 – 14.

[5] Department of Agriculture and Fisheries. (n.d.). Biosecurity standards for poultry farms. Retrieved from (link unavailable)

[6] Godfray, H. C. J., Beddington, J. R., Crute, I. R., Haddad, L., Lawrence, D., Muir, J. F., ... & Toulmin, C. (2010). Food security: The challenge of feeding 9 billion people. Science, 327(5967), 812-818.

[7] Godfrey Chagwiza, Chipo Chivuraise, and Christopher T. Gadzirayi (2016). A Mixed Integer Programming of Poultry Feed Ration Optimisation Problem Using the Bat Algorithm. Advances in Agriculture Volume 2016, Article ID 2313695, 6 pages Hindawi Publishing Corporation http://dx.doi.org/10.1155/2016/2313695

[8] Goran Grzonic, Agnieszka Piotrowicz-Cieslak, Anggnieszka Klimkowicz-Pawlas, Rafal L. Gorny, Anna Lawniczek-Walczyk, Lidia Piechowicz, Ewa Olkowska, Marta Potrykus, Maciej Tankiewicz, Magdalena Krupka, Grzegorz Siebielec, Lidia Wolska (2023). Intensive poultry farming: Areview of the impact on the environment and human health. Science of Total Environment, Science Direct, Elsevier, Vol.858, Part 3, 1 February 2023, 160014.

[9] Hamza Belkhanchi, Younes Ziat, Maryama Hammi, Ousama Ifguis (2023). Formulation, optimization of a poultry feed and analysis of spectrometry, biochemical composition and energy facts. South African Journal of Chemical Engineering 44 (2023), 31 – 41. : www.elsevier.com/locate/sajce. 1026-9185/© 2023 Published by Elsevier B.V. on behalf of South African Institution of Chemical Engineers.

[10] Lashari, M. H., Habib, M. A., & Hong, W. C. (2018). Poultry health management using Internet of Things (IoT) and Machine Learning (ML). International Journal of Advanced Computer Science and Applications, 9(5), 251-258.

[11] Lixin Shen, Fucheng Li, Congcong Li, Yumin Wang, Xueqi Qian, Tao Feng, Cong Wang (2020). Inventory Optimization of Fresh Agricultural Products Supply Chain Based on Agricultural Superdocking. Journal of Advanced Transportatio https://doi.org/10.1155/2020/2724164

[12] Martin Hilmi, Frands Dolberg and Brian Clarke (2019). Product and profit from poultry. Diversification booklet number 3 Second edition. ISBN 978-92-5-107064-2 https://www.researchgate.net/publication/331174848

[13] Mathias A. Onabid and Therence A. Tchoffo (2018). Maximizing profit in the poultry farming sector: An application of the robust linear programming technique. African Journal of Mathematics and Computer Science Research, Vol. 11(6), pp. 87-95, September 2018 DOI: 10.5897/AJMCSR2018.0750 Article Number: 336955358489 ISSN: 2006-9731

[14] Milena Milojević, Aleksandra Milošević, Goran Stanišić, Suzana Knežević and Maja Došenović Marinković (2024). Systematic studies on tetra SL hybrid hen technology and rearing for chicken welfare. African Journal of Biotechnology,

[15] N D Wahyono, N. D. and Utami, M. M. D. (2018). A Review of the Poultry Meat Production Industry for Food Safety in Indonesia. Journal of Physics: Conference Series 953 (2017) 012125 doi :10.1088/1742-6596/953/1/012125

[16] Narrod, C., Zinsstag, J., & Tiongco, M. (2009). Animal production systems: Integrated assessment of production systems. Revue Scientifique et Technique, 28(2), 547-554.

[17] Olalere Olusegun Abayomi, Alara Oluwaseun Ruth, Mohamed Saad Bala, and Mohamed Farag Twib (2016). A Multi-Criteria Proximal Bundle-based Optimization Approach to Chick-Mash Feed Formulation. Research & Reviews: Journal of Agriculture and Allied Sciences, Volume 5, Issue 1 August 2016. e-ISSN:2347-226X p-ISSN:2319-9857

[18] Priyaranjan Mallick , Kamalakanta Muduli, Jitendra Narayan Biswal and John Pumwa (2020). Broiler Poultry Feed Cost Optimization Using Linear Programming Technique. Journal of Operations and Strategic Planning 3(1) 31–57, 2020. DOI: 10.1177/2516600X19896910 journals.sagepub.com/home/osp

[19] Rajnish Kler, Roshan Gangurde, Samariddin Elmirzaev, Md Shamim Hossain, Nhut V. T. Vo , Tien V. T. Nguyen, and P. Naveen Kumar (2022). Optimization of Meat and Poultry Farm Inventory Stock Using Data Analytics for Green Supply Chain Network. Hindawi Discrete Dynamics in Nature and Society Volume 2022, Article ID 8970549, 8 pages https://doi.org/10.1155/2022/8970549

[20] Robyn G. Alders, Sarah E. Dumas, Elpidius Rukambile, Godfrey Magoke, Wende Maulaga, Joanita Jong, Rosa Costa (2018). Family poultry: Mulptiple roles, systems, challenges, and options for sustainable contributions to household nutrition security through a planetary health lens Maternal & Child Nutrition, Vol. 14, Issue S3/e12668. https://doi.org/10.1111/mcn.12668. Published: 17 October 2018. Wiley Online Library. https://onlinelibrary.wailey.com.

[21] Smith, P., Martino, D., Cai, Z., Gwary, D., Janzen, H., Kumar, P., ... & Scholes, B. (2015). Greenhouse gas mitigation in agriculture. Philosophical Transactions of the Royal Society B: Biological Sciences, 363(1492), 789-813.

[22] Vinichenko I., Polehenka M., Ortina G., Abuselidze G., Kazarian H., and Vinogradchyi V. (2023). Optimization of production parameters of agricultural enterprises. IOP Conference Series: Earth and Environmental Science 1126 (2023) 012022, doi:10.1088/1755-1315/1126/1/012022