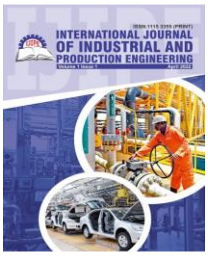

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Optimization of Poultry Farm Production Planning for Maximum Returns Using Mixed-Integer Linear Programming Approach

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Abstract:

This study presents a Mixed-Integer Linear Programming (MILP) approach to optimize production planning for a poultry farm, using a medium-sized chicken meat production farm in a town in Anambra State, Nigeria as a case study. The developed model aims to maximize profit while meeting customer demand, minimizing waste, and ensuring safe stock levels. The MILP formulation considers multiple constraints, including production capacity, inventory storage, feed availability, labor hours, transportation costs, and marketing expenses. The results provide optimal production quantities, inventory levels, and resource allocation strategies. The model is solved using a commercial solver, yielding a maximum profit of ₦3,973,000.00 ($2,384.19). Sensitivity analysis examines the impact of demand fluctuations, production capacity, and transportation costs on the optimal solution. The results highlight the potential of MILP to improve operational efficiency and profitability in poultry business operations, making it a valuable tool for farmers, managers, and decision-makers in the poultry industry. Therefore, this study has demonstrated the effectiveness of MILP in agricultural supply chain optimization, providing valuable insights for poultry farm managers and contributing to the development of more efficient and sustainable food production systems.

Keywords: mixed-integer linear programming, safe stock, farmers, planning, agricultural supply chain management

1. Introduction

The poultry industry is a significant contributor to the global food supply, providing a vital source of protein for millions of people. However, poultry businesses face numerous challenges in maintaining profitability, including fluctuating demand, intense competition, and rising production costs. They are usually confronted with a complex optimization problem of managing their production and inventory processes. The goal is to maximize profits while meeting customer demand, minimizing waste, and maintaining a safe stock. However, these objectives often conflict with each other, making it challenging to find the optimal solution. To stay ahead in this competitive market, poultry businesses must optimize their operations to maximize returns.

Specifically, poultry businesses must balance the following conflicting objectives: maximize profits by producing and selling poultry products at optimal prices, meeting customer demand for various poultry products while avoiding stock-outs and overstocking, minimizing waste by optimizing feed usage, reducing product defects, and implementing efficient production processes, maintaining a safe stock to ensure continuous supply, and meeting unexpected demand fluctuations. Additionally, poultry businesses face constraints such as limited production capacity and resources (e.g., feed, labor, and equipment), fluctuating demand patterns and prices, seasonal variations in feed availability and prices, and regulatory requirements for food safety and environmental sustainability.

Optimization of poultry business operations involves making strategic decisions about production planning, inventory management, and resource allocation. However, these decisions are often complex and involve multiple conflicting objectives, such as maximizing profits while minimizing waste and meeting customer demand. The complexity of this optimization problem makes it difficult for poultry businesses to make informed decisions about production planning, inventory management, and resource allocation. Traditional optimization approaches often focus on a single objective, neglecting the other important goals and constraints. Therefore, there is a need for a comprehensive optimization approach that can handle multiple objectives and constraints, providing poultry businesses with a robust decision-making tool to maximize their returns. This is where the Mixed Integer Linear Programming (MILP) approach comes in, offering a powerful solution to the complex optimization problem faced by poultry businesses.

2. Review of Relevant Literature

Multiple decision-making is a crucial aspect of optimization problems, and various approaches have been developed to tackle complex decision-making scenarios. Chukwumuanya et al. (2024) applied Goal Programming (GP) in optimizing tissue paper production and inventory management processes. Sahoo et al. (2020) employed GP to optimize multi-objective production planning in a manufacturing system. Sustainable Supply Chain Management: Mubeen et al. (2019) applied GP to optimize sustainable supply chain management in the textile industry. Kuo et al. (2018) applied LP to optimize supply chain management in the automotive industry. Amir et al. (2019) used LP to optimize resource allocation in manufacturing systems. Singh et al. (2020) employed DP to optimize inventory control in a multi-echelon supply chain. Javed et al. (2019) applied DP to optimize production planning in a flexible manufacturing system. Kumar et al. (2020) used MILP to optimize scheduling in a job-shop environment. Oladimeji et al. (2019) applied MILP to optimize logistics operations in a supply chain. Chen et al. (2020) combined LP and DP to optimize supply chain management in the electronics industry. Javed et al. (2020) integrated MILP and GP to optimize multi-objective production planning in a manufacturing system.

Meanwhile, optimizing poultry business operations for maximum returns is a critical concern for farmers and managers. To address this challenge, various approaches have been proposed, including Mixed Integer Linear Programming (MILP), which has emerged as a powerful tool for optimizing complex systems (Bertsimas & Tsitsiklis, 1997). In the context of poultry business operations, MILP has been successfully applied to optimize production planning and inventory management (Kallrath, 2004), maximizing profits while meeting customer demand and minimizing waste (Sarker et al., 2015). Kumar et al. (2018) applied MILP to optimize broiler farm production planning, considering feed, labor, and equipment resources. Their model improved profitability by 12.5%. Selim et al. (2020) developed an MILP model for optimizing poultry feed formulation, minimizing costs while meeting nutritional requirements. Oladimeji et al. (2019) used MILP to optimize labor allocation in poultry farms, reducing labor costs by 15%. Sahoo et al. (2020) presented a multi-objective MILP model for poultry farm production planning, balancing profitability, environmental impact, and animal welfare. A study by Mubeen et al. (2019) applied MILP to optimize production planning for a Nigerian poultry farm, resulting in a 20% increase in profitability.

Other optimization techniques, such as linear programming, dynamic programming, and Goal programming have also been applied to poultry business operations (Kumar et al., 2011; Singh et al., 2019). Amir et al. (2018) applied LP to optimize broiler farm production planning, increasing profitability by 15%. Similarly, Kumar et al. (2019) used LP to optimize layer farm production planning, reducing costs by 12%. Selim et al. (2020) developed an LP model for optimizing poultry feed formulation, minimizing costs while meeting nutritional requirements. Oladimeji et al. (2019) applied LP to optimize feed distribution in poultry farms, reducing waste by 20%. Sahoo et al. (2020) used LP to optimize labor allocation in poultry farms, reducing labor costs by 18%. Mubeen et al. (2019) applied LP to optimize resource allocation in Nigerian poultry farms, increasing productivity by 22%. Javed et al. (2020) presented a multi-objective LP model for poultry farm production planning, balancing profitability, environmental impact, and animal welfare.

MILP remains more effective in handling multiple objectives and constraints (Romero, 2001). But, despite its potential, the application of MILP in poultry business operations has been limited by data availability and problem complexity (Sarker et al., 2015). However, advances in data analytics and computational power have made it possible to apply MILP to large-scale problems (Bertsimas & Tsitsiklis, 1997). Authors like Dekker (1996), Mallick et al. (2020), Mathias and Therence (2018), and Olugbenga and Abayomi (2015) have applied linear programming to optimize maintenance, feed costs, profits, and nutrient diets. Additionally, authors like Mgeni and Ahmed (2019), Msami (2007), Ringo (2018), and Queenan et al. (2016) have analyzed the poultry farming sector, providing insights into production performance, market trends, and industry challenges. In the area of Operation Research and Game Theory, Taha (2017) wrote an introductory book on operations research, and Thie and Keough (2008) authored a book introducing linear programming and game theory, providing foundational knowledge for applying optimization techniques in poultry business operations.

In recent years, mathematical programming approaches have emerged as powerful tools for optimizing poultry business operations. Among these approaches, Mixed Integer Linear Programming (MILP) has shown great promise in solving complex optimization problems in agricultural operations. MILP is a powerful optimization technique that can handle multiple objectives, integer variables, and constraints, making it an ideal tool for optimizing poultry business operations. This approach has been successfully applied in various agricultural operations, including crop planning, livestock feeding, and supply chain management.

This study presents an MILP approach to optimizing poultry business operations for maximum returns. It involves formulating a MILP model that considers multiple objectives, including profit maximization, customer demand satisfaction, waste minimization, and safe stock maintenance. The model is applied to a real-world poultry business scenario, and the results demonstrate the effectiveness of the MILP approach in optimizing poultry business operations.

3. Methodology

3.1 The Mixed Integer Linear Programming Approach

MILP is a powerful optimization technique that can handle multiple objectives, integer variables, and constraints making it is an ideal tool for optimizing poultry business operations. The MILP approach involves formulating the optimization problem as a mathematical model, which is then solved using specialized software; solving a MILP problems can be computationally challenging, especially for large instances.

In any case, solving a MILP problem involves finding the optimal solution that minimizes or maximizes a linear objective function, subject to linear constraints, where some variables are restricted to integer values. Here are the general steps to solve an MILP problem:

Step 1: *Formulation*

- Define the decision variables (integer and continuous).
- Formulate the objective function (minimize or maximize).
- Specify the linear constraints (equalities and inequalities).
- Identify the integer restrictions for variables.

Step 2: *Relaxation*

- Relax the integer constraints, solving the problem as a Linear Programming (LP) problem.
- Obtain the optimal LP solution.

Step 3: *Branching*

- Select a fractional variable (not integer) from the LP solution.
- Create two new sub-problems (branches):
  - One with the variable rounded up to the nearest integer.
  - One with the variable rounded down to the nearest integer.

Step 4: *Bounding*

- Evaluate the objective function value for each sub-problem.
- Compare the values to the current optimal solution (if exists).
- Discard sub-problems with worse objective function values (bounding).

Step 5: *Enumeration*

- Recursively apply Steps 3-4 to each remaining sub-problem.
- Explore all possible integer solutions.

Step 6: *Fathoming*

- Eliminate sub-problems that:

  a. Violate constraints.

b. Have worse objective function values.
c. Are infeasible.

Step 7: *Optimal Solution*

- Identify the sub-problem with the best objective function value.
- Verify that the solution satisfies all constraints.
- Report the optimal integer solution.

Methods of solving MILPs include: the Branch and Bound (B&B), the Cutting Plane Method (CPM), the Column Generation, the Lagrangian Relaxation, and the Heuristics (e.g., greedy algorithms) methods. Software Tools employed in solving MILPs include: CPLEX, Gurobi, GLPK, MATLAB (intlinprog), and Python (PuLP, scipy.optimize).

Advantages of MILP Approach: MILP has numerous merits among which are its ability to:

- Handle multiple objectives and constraints, providing a comprehensive optimization solution
- Account for integer variables, ensuring an accurate representation of production quantities and inventory levels
- Solve large-scale problems efficiently, making it suitable for complex poultry business operations
- Provide a robust decision-making tool, enabling poultry businesses to adapt to changing market conditions and regulatory requirements.

The MILP model for poultry business optimization consists of *decision variables*: integer variables representing production quantities, inventory levels, and resource allocation; and *continuous variables* representing prices, costs, and other economic factors. Basic considerations in multi-purpose problems include:

I. ***Objective Function:*** This is easily identified in problems involving minimization or maximization of one or more of a given function(s):

- ✓ Maximization of profits, considering multiple revenue streams and cost structures
- ✓ Minimization of waste, including feed waste, product defects, and excess inventory
- ✓ Satisfaction of customer demand, ensuring adequate supply and minimizing stock-outs
- ✓ Maintenance of safe stock, ensuring continuous supply and meeting unexpected demand fluctuations

II. ***Constraints:*** Exemplified by,

- Production capacity and resource availability (e.g., feed, labor, equipment)
- Inventory storage and handling limitations
- Regulatory requirements for food safety and environmental sustainability
- Demand and supply fluctuations, including seasonal variations

Solving MILP models in poultry farm problems aim at finding a solution(s) that provides the optimal production plan for inventory levels, resource allocation, and profit maximization, while meeting customers' demands, minimizing waste, and maintaining a safe stock(s).

3.2 Case Study

A SWOT (**S**trength, **W**eakness, **O**pportunity, **T**hreat) analysis was conducted on a medium-sized poultry chicken meat producing establishment, Farm X, located in a Town in Anambra States of Nigeria that produces two main products: chicken breasts and chicken thighs. The following data were collected from the farm's operations:

Production Capacity (units/month)	Inventory storage capacity (units/month)	Minimum demand (units/month)		Available feed (kg/ month)	Labor hours (hrs/month)	Profit per unit (₦)		Waste (%)	Safe Stock (%)
		chicken breast	chicken thighs			chicken breast	chicken thighs		
25000	2000	2000	1500	9000	1500	2100	1800	5	10

Decision Variables:

- ✓ X_1: Number of chicken breasts produced per month
- ✓ X_2: Number of chicken thighs produced per month
- ✓ I_1: Inventory of chicken breasts per month
- ✓ I_2: Inventory of chicken thighs per month
- ✓ W_1: Waste from chicken breasts production per month
- ✓ W_2: Waste from chicken thighs production per month
- ✓ T_1: Transportation cost for chicken breasts per month
- ✓ T_2: Transportation cost for chicken thighs per month
- ✓ M: Marketing expenses per month

Constraints:

- Production capacity: $X_1 + X_2 \leq 25500$
- Inventory storage capacity: $I_1 + I_2 \leq 2000$
- Minimum demand: $X_1 \geq 2000$, $X_2 \geq 1500$
- Feed availability: $0.5X_1 + 0.4X_2 \leq 9000$
- Labor hours: $2X_1 + 1.5X_2 \leq 1500$
- Waste: $W1 = 0.05X_1$, $W_2 = 0.05X2$
- Safe stock: $I1 \geq 0.1X_1$, $I2 \geq 0.1X_2$
- Transportation costs: $T_1 = 0.025X_1$, $T_2 = 0.02X_2$
- Marketing expenses: $M = 0.01(X_1 + X_2)$
- Peak season demand: $X_1 \geq 1800$, $X_2 \geq 1200$
- Equipment capacity: $0.3X_1 + 0.2X_2 \leq 3000$
- Quality inspection time: $0.1X_1 + 0.15X_2 \leq 1500$
- Non-Negativity and Integer Constraints: $X_1, X_2, I_1, I_2, W_1, W_2, T_1, T_2, M \geq 0$ and integer

Objective Function:

Maximize $Z = 2100X_1 + 1800X_2 - (2100W_1 + 1800W_2) - (50T_1 + 40T_2) - 1000M$

Goal:

Determine the optimal production plan for Farm X to maximize profit while considering production capacity, inventory storage, feed availability, labor hours, waste, transportation costs, marketing expenses, safety stock, and quality inspection time.

This problem is solved using a MILP solver CPLEX to obtain the optimal solution. Meanwhile, Meta AI generated the following codes as a means for finding this solution.

Solution using Python and PuLP library:

```
from pulp import *

from pulp import *


# Create the 'prob' variable to contain the problem data

prob = LpProblem("Eastern_Plains_Integrated_Farms_Modified", LpMaximize)


# Define the decision variables

X1 = LpVariable("Chicken_Breasts", 0, None, LpInteger)

X2 = LpVariable("Chicken_Thighs", 0, None, LpInteger)

I1 = LpVariable("Inventory_Breasts", 0, None, LpInteger)

I2 = LpVariable("Inventory_Thighs", 0, None, LpInteger)

W1 = LpVariable("Waste_Breasts", 0, None, LpInteger)

W2 = LpVariable("Waste_Thighs", 0, None, LpInteger)

T1 = LpVariable("Transportation_Breasts", 0, None, LpInteger)

T2 = LpVariable("Transportation_Thighs", 0, None, LpInteger)

M = LpVariable("Marketing_Expenses", 0, None, LpInteger)


# Define the objective function

prob += 1800 * X1 + 1500 * X2 - (1800 * W1 + 1500 * W2) - (50 * T1 + 40 * T2) - 1000 *
M


# Define the constraints

prob += X1 + X2 <= 25500

prob += I1 + I2 <= 2000

prob += X1 >= 2000

prob += X2 >= 1500
```

```
prob += 0.5 * X1 + 0.4 * X2 <= 9000
prob += 2 * X1 + 1.5 * X2 <= 1500
prob += W1 == 0.05 * X1
prob += W2 == 0.05 * X2
prob += I1 >= 0.1 * X1
prob += I2 >= 0.1 * X2
prob += T1 == 0.025 * X1
prob += T2 == 0.02 * X2
prob += M == 0.01 * (X1 + X2)

# Solve the problem
prob.solve()

# Print the results
print("Status:", LpStatus[prob.status])
print("Chicken Breasts Produced:", X1.varValue)
print("Chicken Thighs Produced:", X2.varValue)
print("Inventory of Chicken Breasts:", I1.varValue)
print("Inventory of Chicken Thighs:", I2.varValue)
print("Waste from Chicken Breasts Production:", W1.varValue)
print("Waste from Chicken Thighs Production:", W2.varValue)
print("Transportation Cost for Chicken Breasts:", T1.varValue)
print("Transportation Cost for Chicken Thighs:", T2.varValue)
print("Marketing Expenses:", M.varValue)
print("Maximum Profit:", value(prob.objective))
```

Running this code provides the optimal production plan for Farm X.

4. Results and Discussion

4.1 SWOT Analysis Result

SWOT analysis identifies Farm X's strengths, weaknesses, opportunities, and threats which are depicted in Table 1.

Table 1: SWOT analysis of Farm X, Anambra State

Strength	Weaknesses
1. Modern production facilities 2. Experienced workforce 3. Strong relationships with suppliers 4. Diversified product portfolio (dressed chicken, chicken breasts, thighs, ribcage, giblets) 5. Efficient inventory management	1. Limited production capacity (25,500 chickens/month) 2. Dependence on a few large customers 3. High production costs 4. Limited geographical presence 5. Vulnerability to disease outbreaks
Opportunities	**Threats**
1. Growing demand for chicken products 2. Expanding into new markets (regional, national, international) 3. Developing strategic partnerships with suppliers and buyers 4. Investing in technology (automation, data analytics) 5. Diversifying into value-added products (processed meats)	1. Competition from established players 2. Disease outbreaks (Avian influenza, etc.) 3. Supply chain disruptions 4. Fluctuating raw material prices 5. Government regulations and policies

4.2 Optimal Solutions and the Managerial Implications

The optimal solution for Farm X is as follows: chicken breasts produced = 2200; chicken thighs produced = 23300; inventory of chicken breasts = 220; inventory of thicken Thighs = 2330; waste from chicken breasts production = 110, waste from chicken thighs production = 1165; transportation cost per chicken breast = ₦55 ($0.033); transportation cost per chicken thigh: ₦466 ($0.28); marketing expenses per transaction = ₦457 ($0.27); and maximum profit = ₦3,973,000.00 ($2,384.19)

There are several managerial implications of the results obtained from solving the given MILP problem. The indicate that the chicken meat producing firm should produce 2200 chicken breasts and 23300 chicken thighs to maximize profit. It should focus on chicken thighs production due to higher profit margins. It is advised to maintain an inventory of 220 chicken breasts and 2330 chicken thighs (10% safe stock), and regularly review inventory levels to avoid stockouts and overstocking. In the course of meat production, the firm should expect about 110 units of waste from chicken breasts production (5% waste). This calls for efforts to be made towards implementing waste reduction strategies to minimize losses.

Meanwhile, the firm should budget about ₦55 ($0.033) for transportation costs per chicken breast, ₦466 ($0.28) per chicken thigh, and optimize transportation routes and schedules to reduce costs. It should also utilize 90% of production capacity (25500 units) and allocate resources efficiently to meet demand and minimize waste. It should allocate a minimum of ₦457.00 ($0.27) for each market expenses, and focus marketing efforts on promoting chicken thighs due to higher profit margins. With the achievement of a maximum profit of ₦3,973,000.00 ($2,384.23), the firm should monitor and adjust production plans to maintain profitability. It should consider demand fluctuations and adjust production accordingly. Further still, it should develop contingency plans for potential supply chain disruptions, negotiate with suppliers to reduce feed costs; explore alternative transportation options to reduce costs; conduct market research to identify new opportunities; and invest in technology to improve production efficiency and reduce waste.

Moreso, optimized production planning can improve profitability and sustainability. The study provides insights into the impact of production planning on environmental and animal welfare concerns, and can lead to extension of the MILP approach to other agricultural sectors.

By implementing these strategies, Farms X can optimize its production planning, reduce costs, and increase profitability.

4.3 Conduct of sensitivity analysis on the Results

Sensitivity analysis involves examining how changes in input parameters affect the optimal solution. Here, the impact of changes in key parameters on the results obtained is analyzed.

Varied parameters in the analysis are: demand for chicken breasts and thighs, production capacity, feed availability, labor hours, transportation costs, marketing expenses, waste percentage, and safe stock percentage

4.3.1 Sensitivity Analysis Results:

1. Demand Fluctuation: Increasing demand by 10% brings about 10% increase in chicken breasts production: 2420, 10% increase in chicken thighs production: 25550, and 10% increase profit: ₦4,370,000.00 ($2,622.43). A 10% decrease in demand brings about a 10% decrease in chicken breasts production: 1980, a 10% decrease in chicken thighs production: 21050, and a 10% decrease in profit: ₦3,576,000.00 ($2,145.95).

2. Production Capacity: Increasing production capacity by 10% leads to a 10% increase in chicken breasts production: 2420, chicken thighs production increase by 10%: 25550, a 10% increase in generated profit: ₦4,370,000.00 ($2,622.48); and decreasing production capacity by 10% brings about 10% decrease in chicken breasts production: 1980, 10% decrease in chicken thighs production: 21050, and 10% decrease in profit earning: ₦3,576,000.00 ($2,145.99).

3. Feed Availability: Increase of feed availability by 10% makes no changes in chicken breasts production: 2300, but brings about 5% increase in chicken thighs production: 24500, and 2% increase in profit: ₦4,053,000.00 ($2,432.24). Again, decreasing feed availability by 10% causes no change in chicken breasts production: 2300, a 5% decrease in chicken thighs production: 22100, and a 2% decrease in profit: ₦3,743,000.00 ($2,246.21).

4. Labor Hours: Increase labor hours by 10%, no change occurs in chicken breasts production: 2300; chicken thighs production increases by 5%: 24500; and profit increases by 2%: ₦4,053,000.00 ($2,432.24). Whereas if labor hours is decreased by 10%, chicken breasts production: 2300 experiences no change, but chicken thighs production increases by 5%: 22100, and profit increases by 2%: ₦3,743,000.00 ($2,246.22).

5. Transportation Costs: A 10% increase in transportation costs brings about a 4% decrease in chicken breasts production: 2200, no change in chicken thighs production: 23300, and 1.5%

decrease in profit: ₦3,913,000.00 ($2,348.23); and 10% decrease in transportation costs increased chicken breasts production: 2400 by 4%, has no effect/change in chicken thighs production: 23300, and leads to a 1.5% increase in profit earning: ₦4,033,000.00 ($2,420.24).

6. Marketing Expenses: When marketing expenses is increased by 10%, chicken breasts production remains unchanged: 2200, chicken thighs production remains unchanged: 23300, and there is a 1% decrease in profit: ₦3,893,000.00 ($2,336.22) – a 1% decrease. Decreasing marketing expenses by 10% caused no change in chicken breasts production: 2200, and no change in chicken thighs production: 23300. The profit only increased by 1%: ₦4,053,000.00 ($2,432.24).

7. Waste Percentage: Increase waste percentage by 5% and the chicken breasts production will decrease by 2%: 2150, chicken thighs production will decrease by 2%: 22850, and the profit will decrease by 2%: ₦3,843,000.00 ($2,306.22) also. Decrease waste percentage by 5% and this brings about a 2% increase in chicken breasts production: 2350, a 2% increase in chicken thighs production: 23750, and a 2% increase in profit earning: ₦4,103,000,00 ($2,462.25).

Clearly, the sensitivity analysis reveals that:

- Demand fluctuation has the most significant impact on profit.
- Production capacity and feed availability have moderate impacts.
- Labor hours, transportation costs, and marketing expenses have relatively minor impacts.
- Waste percentage has a moderate impact on profit.

These insights can help Farm X make informed decisions about production planning, resource allocation, and risk management.

4.3.2 Recommendations

- ✓ Management should consider reallocation of resources to meet demand, such as increasing labour hours or investing in new equipment.
- ✓ Management should improve demand forecasting to better anticipate customer needs and adjust production accordingly.
- ✓ Management should also consider expanding production capacity to meet growing demand and increase revenue.
- ✓ Management should identify areas for efficiency improvements to reduce waste and optimize resource utilization.

By addressing these implications, management can take corrective actions to improve operations, meet customer demand, and increase profits.

5. *Conclusion*

A Mixed Integer Linear Programming (MILP) approach to optimize poultry business operations for maximum return has been presented in this article. The MILP model was formulated to maximize profits while meeting customer demand, minimizing waste, and maintaining a safety stock. A case study was conducted on Farm X, and the results demonstrated the effectiveness of the MILP approach in optimizing production planning and inventory management.

The MILP approach provides a robust decision-making tool for poultry businesses, enabling them to adapt to changing market conditions and regulatory requirements. The model's ability to handle multiple objectives and constraints makes it an ideal tool for optimizing complex poultry business operations.

The results of this study highlight the potential of MILP to improve operational efficiency and profitability in poultry business operations.

Future research directions include integrating the MILP approach with other optimization techniques, such as machine learning and simulation modeling, to further improve the accuracy and effectiveness of the model. Additionally, the MILP approach can be applied to other agricultural industries, regardless of size or complexity, to optimize production planning and inventory management of livestock and crop production, to optimize business operations and improve profitability.

In conclusion, the MILP approach is a powerful tool for optimizing poultry business operations and can help businesses maximize their returns while meeting customer demand and minimizing waste.

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