

Formulation Of Grower-Stage Broiler Chicken Feeds From Locally Available Materials Via Linear Programming Approach

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Abstract

Introduction: The poultry industry plays a vital role in fulfilling global protein demands, particularly through broiler chicken production.

Objectives: This study focuses on optimizing the formulation of grower-stage chicken feeds using linear programming techniques.

Methods: The goal is to maximize nutritional content while minimizing costs, emphasizing the use of locally available materials near Jasaan, Misamis Oriental. This approach illustrates the effective utilization of local resources to create a cost-efficient and nutritionally balanced feed, crucial for sustainable chicken production.

Results: Fourteen local feed ingredients were identified for the formulation. Using Excel Solver, the study determined an optimal feed composition that costs Php 28.19 per kilogram, consisting of 0.58 yellow maize, 0.024 snail shell, 0.08 molasses, 0.184 rice bran, and 0.163 potatoes per kilogram.

Conclusion: The findings underscore the importance of strategic ingredient selection. Future research should explore additional local ingredients and consider factors such as feed palatability, broiler weight, health status, and production goals to further diversify poultry feed options.

Keywords: feeds, ingredients, grower-stage broiler chicken, linear programming, Excel Solver.

1. Introduction

The poultry industry plays a crucial role in meeting global demands for high-quality protein, particularly by producing broiler chickens [1] [2]. According to the Food and Agriculture Organization of the United Nations (FAO) estimates, global chicken meat production reached over 135 million metric tons in 2020. With that, there is such extensive production, that it's safe to say that there are billions of consumers of chicken worldwide, spanning various cultures, regions, and socioeconomic backgrounds [3].

Central to the success of broiler chicken farming is the formulation of nutritionally balanced and cost-effective feed, especially during the critical grower stage of chicken development [4]. Traditionally, commercial broiler feed formulations rely heavily on imported or specialized ingredients, which may not always be readily available or affordable, particularly in resource-constrained regions [5]. Creating economically viable, nutritionally balanced

diets is one of the biggest problems facing chicken farmers, particularly in the crucial grower stage of the chicken life cycle. Many areas have an abundance of locally accessible feed ingredients and agricultural by-products that are either neglected or forgotten during the feed formulation process [6].

In response to these challenges, there is a growing interest in exploring alternative feed formulations utilizing locally available materials in the area [7]. This approach reduces dependence on expensive imported ingredients and promotes sustainable agricultural practices by utilizing resources within local ecosystems. However, formulating feeds with locally available materials presents its own set of challenges, including ensuring nutritional adequacy, maintaining feed quality, and optimizing cost-effectiveness [8].

Linear programming (LP) offers a powerful mathematical tool to address these challenges by optimizing feed formulations based on predefined objectives and constraints. LP models can maximize the nutritional content of feeds while minimizing costs, thereby facilitating the development of economically viable and nutritionally balanced formulations. By incorporating LP techniques, this study aims to harness the potential of locally available materials in formulating grower-stage broiler chicken feeds. [9] [10].

This study offers important new information about the possible advantages and difficulties of incorporating linear programming techniques into the processes used to formulate poultry feed [11]. The results of this study should help develop sustainable systems for raising chickens by providing useful advice on how to improve feed formulations, maximize resource efficiency, and encourage the use of locally accessible agricultural products [12]. In the end, using linear programming techniques to formulate grower-stage chicken feeds could enhance the global poultry farming industry's financial stability, nutritional value, and environmental sustainability [13].

2. Objectives

The primary objective of this study is to provide a thorough and economical feed formulation plan designed especially for grower-stage broiler chickens. The goal of the study is to lessen dependency on pricey, imported supplies while still meeting the nutritional requirements of the chickens by utilizing locally accessible materials in Misamis Oriental, especially in the municipalities of Jasaan, Balingasag, and Claveria.

The research attempts to determine the best mix of components that lowers manufacturing costs while still meeting the necessary nutritional standards by applying a linear programming approach. It is anticipated that this tactic will improve the broiler pellets' overall performance, resulting in healthier, and more productive chickens. Additionally, by promoting the use of locally sourced materials, the study supports sustainable agricultural practices, potentially leading to a more resilient and self-sufficient poultry industry.

3. Methods

3.1 Preliminaries

To identify the grower-stage broiler chicken feed ingredients that are locally available in the area, a survey among poultry farmers in various places in Misamis Oriental was conducted. The data acquired indicates that only the top 14 feed items are examined in the study. These feed ingredients are maize yellow, snail shell, cassava, molasses (cane), grass meal, peanut meal, cabbage leaves, coconut residue, madre de agua leaves, rice bran, limestone, potatoes, kangkong, and bone meal. Only these ingredients are considered in the formulation of the feed rations.

The survey also indicated that not all of the grower-stage broiler chicken feeds were utilized to purchase the previously mentioned feed ingredients.

For the amount of time and money needed to prepare the substitute feed items, one can determine the number of kilograms per second produced in an hour by dividing one hour by the typical preparation time as shown in Table 1. The hourly labor rate is set at According to the Department of Labor and Employment (DOLE) in Region 10, Php 53.25 hourly minimum wage for employees and workers that are members of the agriculture industry. Assuming that only one worker can prepare every preparation of ingredients, multiply by the maximum preparation hour and labor rate per hour based on the DOLE rate in Region 10. The following formula is used to determine labor costs:

$$\text{Labor Cost} = (\text{Maximum Preparation Hour}) \times (\text{Number of Worker/s}) \times (\text{Labor Rate per Hour}) \quad (1)$$

Hence, the labor cost as mentioned in Table 1, involved in preparing those feed ingredients is taken into account to determine which feed ingredients would result in the lowest overall cost.

In the formulation of the grower-stage broiler chicken feeds, the nutrient content of each ingredient is carefully considered to ensure that the final feed mixture meets the dietary requirements essential for optimal growth and health of the chicken. This involves balancing protein, carbohydrates, fats, vitamins, and minerals in

precise proportions, taking into account the specific nutritional needs of broiler chickens at this stage of development. Failure to follow the recommended nutrient requirement may adversely affect the health of the broiler chicken.

The table provides a detailed overview of various feed ingredients commonly utilized in the

formulation of grower-stage broiler chicken feeds. The amount of time and money needed to prepare the substitute feed items are shown in Table 1. The recommended nutrient requirements for broiler chickens and the amount/kg diet for each feed ingredient are carefully calculated to ensure that the broiler chicken receives a balanced intake of essential nutrients

Table 1: The amount of time and money needed to prepare the substitute feed item

No.	Feed ingredients	Preparation/Activity	Estimated Preparation Time/kilo (minutes)	Estimated Price/ Kilogram (in Php)
1	Yellow maize	Harvesting and shelling then separate the kernels from the cobs.	30	26.5
2	Snail Shell	Harvesting and removing the meat from the shell. Boiling for a few minutes and draining and grinding into small pieces	45	40
3	Cassava	Harvesting and chopping into small pieces	30	26.5
4	Molasses (cane)	Prepare a specific amount of molasses for the mixture (based on the market price)	—	12.5
5	Grass Meal	Harvesting and chopping into small pieces	25	22
6	Peanut meal	Harvesting and grinding groundnut kernels	30	40
7	Cabbage Leaves	Harvesting and chopping the cabbage leaves into small pieces	25	22
8	Coconut Residue	Manual grating of the coconut meat and extraction of coconut milk	30	26.5
9	Madre de Agua Leaves	Harvesting and chopping into small pieces	20	17.75
10	Rice Bran	Buying in the market (based on market price)	—	39
11	Limestone	Pulverizing into a grounding limestone.	45	40
12	Potatoes	Harvesting and cooking for several minutes.	25	22
13	Kangkong	Harvesting and chopping the Kangkong leaves into small pieces	25	22
14	Bone Meal	Collecting and grinding. Boiling at a specific temperature using a pressure cooker; After boiling, pulverized into pieces, and ready for mixture.	90	80

3.2. Determining the Nutrient Requirements for Grower-Stage Broiler Chicken

The formulation of the nutritional diet model is a blend of several feed components required for a broiler chicken's balanced diet. The prototype must meet a series of requirements including availability and nutritional levels, limits, certain substances that must be used, a demand constraint, and financial and physical limitations.

Grower-stage broiler chickens require a balanced diet with essential nutrients to support their growth and development. The main nutrients needed for grower-stage broiler chickens include; yellow maize, snail shell, cassava, molasses, grass meal, peanut meal, cabbage leaves, coconut residue,

Madre de Agua leaves, rice bran, limestone, potatoes, kangkong, and bonemeal.

Table 2 shows the nutritional content of various feed ingredients is carefully outlined, detailing the corresponding amounts of essential nutrients required for optimal broiler chicken growth. These nutrients include crude fat (g/kg), crude protein (g/kg), crude fiber (g/kg), calcium, phosphorus, lysine, methionine, dry matter (g/kg), and ME (kcal/kg).

Table 2: Nutrient contents for the different feed ingredients

Feed ingredients	Amounts								
				Major minerals	Amino Acids				
	Crude fat (g/kg)	Crude protein (g/kg)	Crude fiber (g/kg)	Calcium (g/kg)	P (g/kg)	Lysine (g/kg)	Methionine (g/kg)	Dry matter (g/kg)	ME (kcal/kg)
Maize Yellow	39	83	26	0.3	2.8	2.6	1.7	890	3350
Snail Shell	—	40.81	1.58	315	4.78	1.11	0.76	—	2563
cassava	5.0	33.0	44.0	2.2	1.5	0.2	0.4	880	3450
Molasses (cane)	1.1	40.0	—	8.2	0.8	0.1	0.2	710	2150
Grass Meal	34.2	182.2	209	6.3	3.48	7.1	3.1	917	1390
Peanut meal	65	432	69	1.7	5.9	14.8	5.0	930	2300
Cabbage Leaves	1.2	18.6	11.6	0.67	0.15	0.67	0.14	81	—
Coconut Residue	26.8	14.92	18.34	0.2	0.36	4.4	2.3	65	3020
Madre de Agua Leaves	26.6	182	125	50	4.1	5.3	3.2	920	—
Rice Bran	130	133	130	0.7	13.4	5.7	2.6	874	2980
Limestone	—	—	—	350	—	—	—	—	—

potatoes	20	755	5.5	2.5	2.8	64	19.2	910	2840
kangkong	38	280	120	12.4	4.1	5.2	3.5	940	—
Bone Meal	7.4	42	8.8	220	200	—	—	—	—

Source: [Banerjee (A textbook of animal husbandry, poultry nutrition), Broiler Poultry Feed Cost Optimization Using Linear Programming Technique by Mallick, P et.al., Nutrition and feeding of organic poultry, 2nd edition by Robert Blair]

Table 3 shows the estimated nutrient requirements for broiler chickens, specifically during the growing stage from three to six weeks. These requirements are expressed in amounts per kilogram of diet, covering essential nutrients necessary for optimal growth. The nutrients detailed in Table 2 include crude fat, crude protein, crude fiber, calcium, phosphorus, lysine, methionine, dry matter, and metabolizable energy (ME in kcal/kg). These components are vital for the healthy growth and performance of broiler chickens during this stage.

Table 3: Recommended nutrient requirements for broiler chickens, amount/kg diet

Nutrient requirement	Growing 3 – 6 Weeks
Crude Fat (g/kg)	50
Crude Protein (g/kg)	200
Crude Fiber (g/kg)	35
Calcium (g/kg)	9
Phosphorus (g/kg)	3.5
Lysine (g/kg)	10
Methionine (g/kg)	3.8
Dry Matter (g/kg)	190
ME (kcal/kg)	3200

Source: (Nutrition and feeding of organic poultry, 2nd edition by Robert Blair, page 42)

3.3 Linear Programming Model for Grower-Stage Broiler Chicken Feeds

The formulation of a Linear Programming (LP) model to minimize the cost of feeds while satisfying the nutrient requirements involves identifying each feed ingredient's cost and nutritional content, defining the nutrient requirements for the grower-stage broiler chicken, and setting constraints to ensure these requirements are met. The objective function of the LP model will aim to minimize the

total cost by selecting the optimal combination and quantities of feed ingredients. This approach ensures that the diet provided to the broiler chicken is both cost-effective and nutritionally adequate.

By applying Excel solver, finding a model's optimal solution means effectively using Microsoft Excel's built-in functionality to tackle optimization problems. Excel Solver employs mathematical algorithms to iteratively adjust variable values while respecting constraints, ultimately converging on the optimal solution that minimizes the defined objective function.

Since it is minimization, the value is based on the recommended daily nutrient above, the linear programming models are set up as follows:

$$\text{Minimize } Z = CX_1 + CX_2 + CX_3 + \dots + CX_{14} \quad (2)$$

Where;

Z = is the value for the optimal solution

C = cost of ingredients based on Table 1

X₁, X₂, ... X₁₄ = type of feed ingredients

The recommended nutrients are subjected to the following constraints as stated in Table 2 which equated to the recommended nutrient requirements as mentioned in Table 3, either greater than or equal to the required nutrients. The formula is set up as follows;

$$a_{11}x_1 + a_{12}x_2 + \dots + a_{14}x_{14} \geq 50 \quad (\text{fat}) \quad (3)$$

$$a_{21}x_1 + a_{22}x_2 + \dots + a_{24}x_{14} \geq 200, \quad (\text{protein}) \quad (4)$$

$$a_{31}x_1 + a_{32}x_2 + \dots + a_{34}x_{14} \geq 35, \quad (\text{fiber}) \quad (5)$$

$$a_{41}x_1 + a_{42}x_2 + \dots + a_{44}x_{14} \geq 9, \quad (\text{Calcium}) \quad (6)$$

$$a_{51}x_1 + a_{52}x_2 + \dots + a_{54}x_{14} \geq 3.5, \quad (P) \quad (7)$$

$$a_{61}x_1 + a_{62}x_2 + \dots + a_{64}x_{14} \geq 10, \quad (\text{Lys}) \quad (8)$$

$$a_{71}x_1 + a_{72}x_2 + \dots + a_{74}x_{14} \geq 3.8, \quad (\text{Meth}) \quad (9)$$

$$a_{81}x_1 + a_{82}x_2 + \dots + a_{814}x_{14} \geq 190, \text{ (DM) (10)}$$

$$a_{91}x_1 + a_{92}x_2 + \dots + a_{914}x_{14} \geq 3200, \text{ (ME) (11)}$$

$$X_1 + X_2 + X_3 + \dots + X_{14} \leq 2 \text{ (Mixture) (12)}$$

$$12.5X_4 \leq 1 \quad \text{(molasses) (13)}$$

$$\text{Non-Negativity } x_1, x_2, \dots, x_{14} \geq 0 \text{ (14)}$$

Where:

C = cost of ingredients based on Table 1

X = type of feed ingredient

a = amount of nutrient type

Based on the nutrient content and costing information shown in Table 1, Table 2, and Table 3, the formula (3 to 14) is greater than or equal to the required nutrients and additionally, the mixture is the total of all the ingredients is less than or equal to the specific kilograms set and lastly, the cost of molasses is set to less than or equal to 1 Php.

Hence, the linear programming (LP) model with 14 decision variables for feed ingredients, eleven (11) constraints for nutrient requirements, a total mixture of all ingredients and molasses as a binder included in the constraints provides an efficient solution to minimize the objective function while adhering to specified constraints as shown in Figure 1.

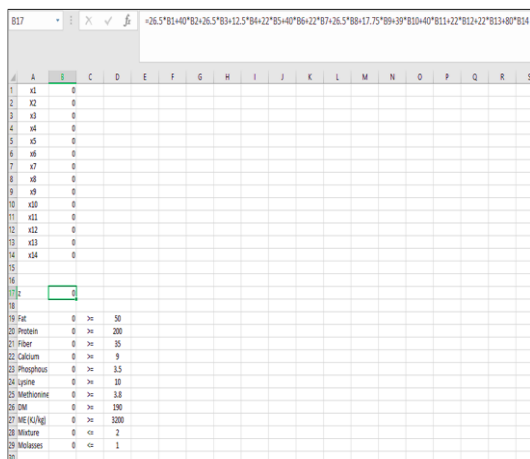


Figure 1: Excel Solver set-up

4. Discussion

There are 30-least combinations of the fourteen (14) feed ingredients that were taken to come up with feed rations for grower-stage broiler chicken. Table 4 shows the combinations that were taken 8 (9,10, 11, 12, 13, and 14 at a time) that minimize the cost of feed ingredients while satisfying the nutrient

requirement. LP models are formulated by considering each possible combination and then solving the resulting LP models using the Excel solver as mentioned in Figure 1.

Table 4: Amount of feed ingredient used for the 30 least-cost alternative feed rations for grower stage broiler chicken and the corresponding costs.

In gr e d i e n t s	Ration																														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
M a i z e Y e l l o w	0	-	0	0	0	-	-	-	0	0	0	-	-	-	0	-	-	-	0	-	-	-	0	-	-	0	0	0	-	-	-
	5	-	6	8	3	-	-	-	8	4	3	-	-	-	4	-	-	-	2	-	-	-	2	-	-	2	2	2	-	-	-
	8	-	1	7	9	-	-	-	7	4	9	-	-	-	4	-	-	-	6	-	-	-	6	-	-	6	9	6	-	-	-
S n a i l s h e l l	0	0	-	0	0	-	0	0	-	-	0	0	-	-	-	-	-	-	-	-	-	0	-	-	-	-	0	-	0	0	0
	0	0	-	0	0	-	0	0	-	-	0	0	-	-	-	-	-	-	-	-	-	0	-	-	-	-	0	-	0	0	0
	2	2	-	8	8	-	2	2	-	-	8	6	-	-	-	-	-	-	-	-	3	-	-	-	-	5	-	8	6	5	
C a s s a v a	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M o l a s s e s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
G r a s s m e a l	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	0
	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	9
	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	9
	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	9
	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	9
P e a n u t s e e d	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C a b b a g e L e	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

5 Conclusion

In summary, this study effectively illustrates the possibility of utilizing locally accessible resources to optimize feed composition for grower-stage broiler chickens. Using a linear programming technique, a financially sensible plan that strikes a balance between economic factors and nutritious content was feasible. The results highlight how crucial it is to choose ingredients strategically to maximize growth performance and save expenses. This strategy helps ensure that chicken production is sustainable and offers a framework that can be modified to fit various situations based on the available resources. It is recommended that future studies explore the inclusion of alternative local ingredients that have not yet been widely considered in broiler feed formulation. Additionally, the palatability of feeds, the weight of the broiler chicken, health status, and production goals of the chicken are considered. This could help in diversifying the feed options available to poultry farmers.

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