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OPTIMIZATION OF BIOFEED PLAN AND SPACE REQUIREMENT FOR RABBIT (*Oryctolagus cuniculus* L.)

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ABSTRACT

Rabbits has an advantageous feeding nature and gastrointestinal tract. By employing feeds derived from biomass (i.e., agro by-products and locally-grown crops), the breeding expenses could also reduced. However, a biofeed plan (a diet derived from biomass ingredients) must be formulated satisfying the rabbits' nutritional needs at minimum cost of production. Space requirement was also another factor that could affect the rabbit's growth. Hence, this study aimed to optimize a biofeed plan and space requirement for rabbits. Treatments were the following: (Factor A) space requirements and (Factor B) CP:CF diet levels organized in a 3 x 4 Factorial RCBD. The thirty-six (36) Californian White x Local (CWxL) rabbits at age of five (5) weeks were divided into three (3) blocks randomly that were breed under three (3) different growing conditions (i.e., air-conditioned room, open rabbitry housing and under the trees' shade). Results of the simplex method optimization revealed that the feeds' prices (€0.27, €0.29 and €0.30 per 1 kg biofeed) were minimized while satisfying the required nutrients. Likewise, the rabbits in medium and small cages fed with commercial feeds were statistically higher from the other treatment combinations in terms of feed conversion efficiency (FCE).

Key words: Biofeed Plan, Californian White, Optimization, Rabbit Pellet, Space Requirement.

INTRODUCTION

Rabbit breeding industry is considered to be an emerging agricultural practice in the Philippines. This was just recently given an attention by the nation's Department of Agriculture (DA) after the outbreak of African Swine Fever (ASF) – finding an alternative meat to replace pork in the local markets.

Rabbit by nature is an herbivorous animal. By taking advantage on their gastrointestinal and physiological aspect, production cost from commercial feeds can be minimized. An economical pellet comparable with the commercial feeds could be formulated by using optimum values of feedstock that achieve an effective combination of diet at minimum cost (Singh and Saxena, 2015). In this connection, simplex method for linear programming was used to determine these optimum values in consideration with the ingredients' local costs, feed contents, and nutrient needs of the livestock.

Moreover, space requirement must be considered in the breeding of animals. The Philippine Agricultural Engineering Standard (PAES) already set considerations in the design of optimum areas required for common livestock yet no standardized sizes are set for the rabbits. However, as indicated by Matics *et al.* (2004), the rabbits are also likely to perform differently in varying stocking densities. Hence, spacing or stocking density is a vital factor considered in the optimization for the rabbit's growth performance.

This study aimed to optimize a biofeed plan (a diet derived from biomass ingredients) and space requirement for rabbits, specifically:
(1) formulate a pelleted diet derived from biomass ingredients satisfying the rabbits' nutritional requirements using simplex method optimization; and
(2) evaluate rabbits' growth performance with varying biofeed formulations and space requirements.

MATERIALS AND METHODS

Local Breeding Environments and Rabbit Samples

The experiment was carried out at the Jabez Marketing Cooperative (JMC) Rabbitry at San Jose City, Nueva Ecija, Philippines from February 2019 – April 2019. A total of thirty-six (36) CWxL rabbits (considering both buck and doe) at age of five (5) weeks were divided into three (3) blocks randomly. The three (3) blocks were designed to have varying breeding environments. The 1st block was set on an enclosed room with the lowest temperature records (20.50°C lowest – 28.20°C highest). Then, the 2nd block was set on an open rabbitry housing (23.50°C lowest – 32.50°C highest). Moreover, the 3rd block was set under the trees' shade with the highest temperature records (25.70°C lowest – 35.50°C highest).

Simplex Method for Biofeed Plan Optimization

Simplex method was done in Microsoft Excel - Optimization Software in order to obtain the optimum quantities for the biomass feedstuffs at a minimum cost. In this process, the objective function was minimizing the cost of biofeed. It was the function of feeding cost (cost of ingredient P_i) and amount of ingredient (X_i) that was considered for the system of equations formulated. Furthermore, it was subjected to constraints to maximize weight gain as a function of nutrients (CP, CF, C_{FAT}, ADF, and NDF) provided by the ingredients. After inputting the system of equations, Microsoft Excel solved the optimization problem through its "Data Solver" application.

Biofeed Plan Objective Function

$$C_{min.} = \sum_{i=1}^{n} (P_i * X_i) \qquad (1)$$

Biofeed Plan Constraints

CF: $$\sum_{i=1}^{n} (CF_i * X_i) \leq CF_x \qquad (2)$$

CP: $$\sum_{i=1}^{n} (CP_i * X_i) \leq CP_x \qquad (3)$$

C_{FAT}: $$\sum_{i=1}^{n} (C_{FAT\,i} * X_i) \leq C_{FAT\,x} \qquad (4)$$

ADF: $$\sum_{i=1}^{n} (ADF_i * X_i) \leq ADF_x \qquad (5)$$

NDF: $$\sum_{i=1}^{n} (NDF_i * X_i) \leq NDF_x \qquad (6)$$

Molasses: $m \leq 0.03$ kg or 30 g (7)

Total Biofeeds: $$\sum_{i=1}^{n} X_i = 1 \text{ kg or } 1000 \text{ g} \qquad (8)$$

where:

$C_{min.}$ = minimum cost of ingredients, ₱
P_i = unit cost of ingredient *i*, ₱/kg
X_i = amount of ingredient *i*, kg
CF_i = crude fiber of ingredient *i*
CF_x = limit of crude fiber for Factor B_x
CP_i = crude protein of ingredient *i*
CP_x = limit of crude protein for Factor B_x
C_{FATi} = crude fat of ingredient *i*
C_{FATx} = limit of crude fat for Factor B_x
ADF_i = acid detergent fiber of ingredient *i*
ADF_x = limit of acid detergent fiber for Factor B_x
NDF_i = neutral detergent fiber of ingredient *i*
NDF_x = limit of neutral detergent fiber for Factor B_x
m = amount of molasses, kg

Feed Formulations on Rabbits

There were two (2) types of feeds that were used in the study (i.e., biofeeds and commercial feeds). The biofeeds were formulated through optimization process and further divided into three (3) biofeed plan formulations based on their CP:CF ratio compositions (i.e., low, average and high CP:CF diet levels).

Space Requirements on Rabbits

Individual cages was designed following the recommended cage height of 406.4 mm (16") with a constant cage length of 508 mm (20"). In order to determine the optimum space requirement or stocking density for rabbits, three (3) types of cages were fabricated:
(1) small cages = 254 mm x 508 mm x 406.4 mm (10" x 20" x 16") for one rabbit*
(2) medium cages = 381 mm x 508 mm x 406.4 mm (15" x 20" x 16") for one rabbit*
(3) large cages = 508 mm x 508 mm x 406.4 mm (20" x 20" x 16") for one rabbit*
*1 rabbit per 1 cage was employed in order to observed the FCEs of individual samples with lesser error compared to group cages.

Composition of Pelleted Biofeeds and Chemical Analysis

Table 1 shows the composition of the optimized biofeed plans.

Table 1: Biomass ingredients for the three (3) biofeed plans

INGREDIENTS	AMOUNT (g of biomass / 1 kg of biofeed)		
	Low CP:CF Diet Level	Average CP:CF Diet Level	High CP:CF Diet Level
Glycine Max Meal	353.94	424.85	495.764
Ipomea aquatica	123.08	61.57	0.054
Molasses	30.00	30.00	30.00
Moringa oleifera	19.33	19.43	19.522
Pennisetum purpureum	473.65	464.15	454.66
TOTAL	1000.00	1000.00	1000.00

Moreover, in proximate analysis, it was expected that the %CP had highly significant differences among each other due to varying amount of biomass ingredients used in each biofeed plans. Note that there were three (3) levels of CP:CF diets and these were assigned at low, average and high amounts. Low diet level used least amount of CP feedstuffs source (i.e, soybean meal) while high diet level used highest amount of CP feedstuffs source.

Statistical Analysis

The FCEs were subjected to Analysis of Variance (ANOVA) introducing two (2) factorial experiment: Factor A (Space Requirements) & Factor B (Biofeed Plans). A two-way ANOVA at 1% and 5% level of significance was employed and comparison among treatment means was made using Fisher's Least Significant Difference (LSD) Test.

RESULTS AND DISCUSSION

Optimized Pelleted Diet

An optimum diet was formulated using simplex method optimization by minimizing the objective function (Equation 1) subjected to nutrient constraints (Equations 2 – 8). The minimized cost of production for the three (3) biofeed plans are shown at Table 2.

Table 2: Minimized costs for the three (3) biofeed plans

INGREDIENTS	COST OF INGREDIENTS (₱)		
	Low CP:CF Diet Level	Average CP:CF Diet Level	High CP:CF Diet Level
Glycine Max Meal	10.62	12.75	14.87
Ipomea aquatica	2.46	1.23	0.0011
Molasses	0.45	0.45	0.45
Moringa oleifera	0.39	0.39	0.39
Pennisetum purpureum	0.95	0.93	0.91
TOTAL	14.87 (€0.27)	15.75 (€0.29)	16.62 (€0.30)

Growth performance at varying biofeed plans and space requirements

Table 3 revealed that the rabbits in medium and small cages fed with control (i.e., commercial feeds) were statistically higher from the other treatment combinations in terms of FCE. Moreover, the lowest FCE's was recorded for those rabbits placed in medium cages and fed with a biofeed plan at low level diet. ANOVA revealed that only the control (i.e., commercial feeds) produced the highest FCE's. The poor performance of the three (3) biofeed plans in terms of FCE could be due to absence of a premix (i.e., amino acids and minerals). Note that the biofeed plan was only formulated considering biomass ingredients only – hence, composed of agro by-products and locally-grown crops only (i.e, formulated without any premix added due to its unavailability at rural areas).

Table 3: Space (Factor A) & biofeed plan (Factor B) two-way table of FCE's ($g_{\text{weight gain}}$ /g_{feeds}) means

FACTOR B (Biofeed Plan)	FACTOR A (Space Requirement)			B's Means
	Small Cage	Medium Cage	Large Cage	
Low CP:CF Diet Level	0.215^{f}	0.191^{f}	0.229^{ef}	0.212
Average CP:CF Diet Level	0.322^{cd}	0.338^{bc}	0.292^{cde}	0.317
High CP:CF Diet Level	0.250^{def}	0.352^{bc}	0.361^{bc}	0.321
Commercial Feeds	0.404^{ab}	0.471^{a}	0.348^{bc}	0.408
A's Means	0.298	0.338	0.308	

Means not sharing small letter in common differ significantly by LSD Test at 5% level of significance (interaction effect).

CONCLUSIONS

Results of simplex method optimization revealed that the feeds' prices for low, average and high CP:CF Diet Levels were minimized at €0.27, €0.29 and €0.30 per 1 kg biofeed, respectively. The rabbits in medium and small cages fed with control (i.e., commercial feeds) were statistically higher from the other treatment combinations in terms of FCE.

Moreover, even though the rabbits fed with biofeeds also produced a weight gain, it was recorded to have lower FCE's compared with the commercial.

RECOMMENDATION

Since, the three (3) biofeed plans are diets formulated with ingredients that easily acquired by the local rabbit breeders, it was not utilizing any premix. Note that premix and other nutrient additives are not present in those remote areas and rural localities in the Philippines. Recommendations for further studies could be also considered the inclusion of premix, but at lower concentrations only.

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Context and objectives: The study aimed to optimize biofeed plan and space requirement for raising meat rabbits.

Methods : Mathematical modeling using a simplex method for optimization was employed in this study using Microsoft Excel.

3 Levels of Space Requirement, 4 Types of Feeds

Results :

Table 2: Minimized costs for the biofeed plans

INGREDIENTS	COST OF INGREDIENTS (₱)		
	Low CP:CF Feedplan	Average CP:CF Feedplan	High CP:CF Feedplan
Glycine Max Meal	10.62	12.75	14.87
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Molasses	0.45	0.45	0.45
Moringa oleifera	0.39	0.39	0.39
Pennisetum purpureum	0.95	0.93	0.91
TOTAL	14.87 (€0.27)	15.75 (€0.29)	16.62 (€0.30)

There were 5 main ingredients used in three types of biofeed plan. These feedplans were categorized as low, average and high crude protein and fiber.

Table 3: FCE's (g weightgain /g feeds) means for space requirement (Factor A) & biofeed plan (Factor B)

FACTOR A (Space Requirement)	FACTOR B (Biofeed Plan)				A's Means
	Low CP:CF Feedplan	Average CP:CF Feedplan	High CP:CF Feedplan	Commercial Feeds	
Small Cage	0.215^{f}	0.322^{cd}	0.250^{def}	0.404^{ab}	0.298
Medium Cage	0.191^{f}	0.338^{bc}	0.352^{bc}	0.471^{a}	0.338
Large Cage	0.229^{ef}	0.292^{cde}	0.361^{bc}	0.348^{bc}	0.308
B's Means	0.212	0.317	0.321	0.408	

Means not sharing small letter in common differ significantly by LSD Test at 5% level of significance (interaction effect).

Feed conversion efficiency is used to determine the fastest weight gain among the samples. Rabbits fed with commercial feeds under medium and small cages were statistically higher compared with other treatments.

Take home message : Common crops in Philippines can be used in feeding meat rabbits. Rabbits can be raised more efficiently compared with other livestocks even without grain. Philippines should create research centers and academic courses focusing for rabbit meat production.