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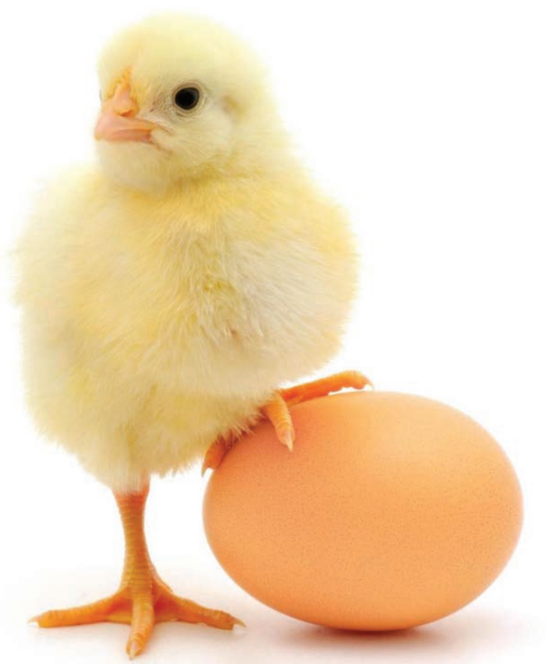

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# Research Article
# The Response of Mule Ducks and Economic Implications when Fed at Different Times of Post Hatch

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## Abstract

**Objective:** This study aimed to evaluate the effect of early post hatch feeding on the growth performance and economic implication of Mule ducks. **Materials and Methods:** A total of 48 newly hatched Mule ducklings were used in this experiment. Economic principles such as average physical product (APP), marginal physical product (MPP), feed cost (FC), value of marginal product (VMP) and income over feed cost (IOFC) was calculated. The parameters investigated were total feed cost, revenue and margin over feed cost. **Results:** Treatments did not influence the APP, MPP, FC, VMP and IOFC over the 9 weeks period (p>0.050). IOFC was found to be negative from 7-9 weeks for all treatments. However, the relationship between the VMP and FC indicated that the VMP increased in a decreasing trend during the starter phase and between weeks 5 and 6 both were equal (VMP = FC). **Conclusion:** The theoretical relationship between the VMP and FC revealed that if finisher diet is fed from 6-9 weeks then the cost of the feed ingredient should not exceed \$1.00TTD kg$^{-1}$. The study suggested that a starter and grower feed should not be fed after 3 and 6 weeks; respectively. However, if production is to be continued until 9 weeks a finisher feed is recommended and cost of feed ingredients should not exceed \$1.00TTD kg$^{-1}$.

Key words: Cost implications, feed cost, post hatch, value of the marginal product, poultry feed

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

## INTRODUCTION

Duck production in Trinidad and Tobago is showing an upward trend due to genetic improvements and introduction of modern technology, there is a shift from backyard system to semi-intensive and intensive systems for commercial purposes[1]. Additionally, Mule ducks are now being harvested at 63 days with an expected market weight of 3 kg[2]. However, in this system feed wastage is one of the major concerns that adversely affect the feed intake and feed conversion ratio which influence the profit margin. Globally and locally, the poultry sector is also experiencing economic pressures due to the rise in the prices of feed ingredients; particularly the price of protein[3]. Feed cost accounts for 60-70% of the total cost of production and any attempt to reduce feed cost may lead to the reduction in the total cost of production[3]. This situation has led to bridge the gap to bridge the knowledge gap between feed cost and production management in the poultry feed industry by utilizing an economic approach.

Growth and development are vital features which have economic implication for domestic animals farmed for food. These features influence the saleable meat yield and value of the animal[4]. In the poultry industry, an important selection criterion is growth intensity which is often used for young poultry feed and nutrition[5]. Furthermore, growth parameters must be closely monitored since feeding on the first day of life significantly affects growth, feed efficiency, uniformity and cost of production[6]. Thus, early post hatch feeding in chicken improved the body weight, muscle yield and reduced the production cost[7].

Starter, grower and finisher is the most popular feeding phase used in duck production[8]. Further, duration of using particular feed type in poultry production may lead to economic benefits[9]. The economic principles such as marginal physical product, marginal value product and income over feed cost are applied for assessing the economic implication of these interventions within the duck industry. Although these principles are popular they have been rarely employed by researchers in the areas of nutrition and production[9]. The marginal physical product (MPP) refers to the change in output associated with an incremental change in the use of an input; marginal value product (MVP) is the value of additional output resulting from the use of one more unit of variable input[10]. Thus, MVP represents the added value of meat expected from each additional unit of feed input. Economists suggest that producers should be willing to continue investing in a feed as long as the added value of meat produced (MVP) is greater than the added cost of the feed input[11]. The relationship between the feeding time and the amount can influence the cost of production in the poultry industry.

However, application of the economic principle in duck production in the humid tropics is not documented. This study, therefore; evaluated the growth response of Mule ducklings and economic implication when fed at different times of post-hatch. The specific objective was to determine the relationship between live body weight and feed intake with the age of the bird. Also to examine the relationship between the marginal value product and the feed cost among the four different treatments to harvest at 63 days.

**Theoretical framework:** Production may be defined as the process of converting the input into output using technology. Economists usually define technology as a stock of available techniques or a state of knowledge concerning the relationship between inputs and a given physical output. The production function is defined as a relation between quantities of inputs that an entrepreneur employs and the quantity of output that is produced[10]. A production function for each vector of inputs described the amount of output that can be produced[10]. Various measures of productivity can be derived from the production function. These include the average productivity curve and the marginal productivity curve. Productivity is a measure of output(s) per unit of the input(s) used to produce the output(s).

Average product is defined as the total product divided by the number of inputs required to produce it[11]:

$$AP_x = \frac{TP}{x_i} = \frac{q}{x_i}$$

Where:

q : Output

$x_i$ : Level of inputs

$$AP = \frac{TP}{x}$$

The marginal productivity of $x_i$ is the change in output associated with a small change in the utilization of $x_i$. Marginal productivity of $x_i$ is defined as the partial derivative of f(x) with respect to $x_i$. When f(x) is differentiable[11]:

$$MP_{xi} = \frac{\partial f(x)}{\partial x_i}$$

Margin over feed cost is defined as a measure used to determine productivity on a farm. It is calculated by using the following formula:

MOFC = Price x body weight of duck-feed cost[12]

Economic efficiency is a state in which all resources are optimally allocated in the best possible way to avoid wastage (i.e the ability to combine inputs and outputs in optimal proportions)[12]. On the other hand, economic productivity is a measure of the ratio of the efficiency of inputs to outputs[12].

The law of diminishing returns states that as units of a variable input are added to units of one or more fixed outputs after a point, each incremental unit of the variable input produces less and less additional output. Moreover, as units of the variable input are added to units of outputs, the proportion changes between the input and output[10].

## MATERIALS AND METHODS

**Animals and experimental design:** Trinidad is located within the humid tropics at 10 ½° North latitude and 6 ½° west longitude. Daily temperatures range from 24.1-36.15°C and the average humidity is 80.21%. There are two seasons: a dry season from January to May and a rainy season from June to December. This study was conducted during the rainy season at The University of the West Indies Field Station (UFS) located in Valsayn (10°38'15"North 61°25'39"West), a town in northern Trinidad.

Forty eight newly hatched Mule ducklings were purchased from a local hatchery for this experiment. Prior to transportation ducklings were packed in 4 boxes containing 12 ducklings in each box. One box of the 12 Mule ducklings were given 100 g of starter feed 3 h after clearing the incubator and the Ducklings were transported to the experimental facility at the University Field Station. The ducklings were randomly assigned to four groups (3, 24, 36, 48 h post-hatch) according to four post-hatch feeding time regime (T1:3 h, T2: 24 h, T3: 36 h and T4:48 h). Each treatment had 6 replicates, each with two Ducklings (12 Ducklings per treatment). Feed was offered according to National Research Council (NRC) standards and refusal was measured daily to determine feed intake; water was provided *ad libitum*[13]. The experimental period was 63 days, harvest practice by industry in Trinidad.

**Housing and animal management:** The birds were raised in an open sided naturally ventilated housing system. Dimension of the cages was 48 $cm^2 \times 24$ $cm^2$. Treatment 1 received both water and feed 3 hrs post-hatch while the other treatments received water only and no feed until 24, 36 and 48 h, respectively post-hatch. No vaccination was done according to local production practices. A density of two birds per square meter was used. These crates were made of metal with mesh floors and were housed in a standard open sided house. The crates contained one commercial waterer and one commercial feeder. For the calculation of feed conversion ratio, weight of the each bird was recorded weekly. Ducks were observed daily to control pests and diseases. A commercial duck ration formulated primarily from soybean and corn was weighed and fed once per day in flat feeders in the crates. The ingredients and nutrient composition of the feeds used in the experiment are shown in Table 1.

**Growth performance:** Ducklings were fed starter ration for the first 21 days. From 22-63 days, the ducks were fed a grower ration. At seven days ducklings were weighed using an electronic scale (OHAUS IR SENSOR). This procedure was repeated on a weekly basis until harvest age (63 days). Feed conversion ratio during the respective weeks and the overall period was calculated as the ratio between units feed intake and unit weight gain.

**Statistical analysis and calculation:** Data were analyzed using one-way analysis of variance (ANOVA) with the help of Minitab 18 software for window[14]. Regression analysis was conducted using the Maximum Likelihood Estimation Technique (MLET). During the experimental period, data were corrected for heteroskedasticity and autocorrelation using Newey-West standard errors (HAC) estimators. Data were estimated using the econometric software Gnu Regression, Econometric and Time Series[15]. Akaike Information Criterion was used for Model selection. Significance was defined based on the 95% confidence level. Feed intake (FI) was calculated as:

$$FI = \frac{\text{Feed given - feed refused}}{\text{No. of ducklings}}$$

Parameters investigated were total feed cost (FC), revenue and margin over feed cost (MOFC).

**Economic implication:** At the end of the experiment, the following was calculated according to the method described by Rushton[9]:

$$\text{Average physical product (APP)} = \frac{\text{Body weight}}{\text{Feed intake}}$$

$$\text{Marginal physical product (MPP)} = \frac{\triangle\text{body weight}}{\triangle\text{feed intake}}$$

$$\text{Value of the marginal product (VMP)} = \$13.50\text{TTD} \times \text{MPP}$$

$$\text{Feed cost (FC)} = \text{Price of feed} \times \text{accumulated feed intake}$$

Table 1: Composition of starter and grower diet

| Ingredients (g kg$^{-1}$ DM) | Starter | Grower-finisher |
|---|---|---|
| Soyabean meal (470 g CP kg$^{1}$ DM) | 415.2 | 251.2 |
| Ground corn | 356.4 | 548.1 |
| Rice bran | 80.0 | 100.0 |
| Broken rice | 60.6 | 0.0 |
| Bran shorts | 30.0 | 45.0 |
| Soyabean oil | 15.0 | 15.0 |
| Dicalcium phosphate | 13.5 | 11.4 |
| Limestone | 12.8 | 14.5 |
| Broiler premix-9943 | 7.5 | 7.5 |
| NaCl (salt) | 4.6 | 2.8 |
| Bentonite | 3.0 | 3.0 |
| Luprosil salt | 0.9 | 0.9 |
| Methionine dl | 0.4 | 0.6 |
| **Calculated chemical composition (g kg$^{-1}$ DM)** | | |
| Dry Matter* | 889.00 | 893.000 |
| ME (kcal g$^{-1}$ DM) | 2.85 | 3.038 |
| Crude Protein* | 224.00 | 178.000 |
| NDF* | 164.00 | 330.000 |
| Ca | 10.50 | 10.500 |
| Available P | 4.60 | 4.000 |
| Ca: Available P | 2.30 | 2.600 |
| Lysine | 15.00 | 10.600 |
| Methionine | 4.66 | 4.050 |
| Methionine+cysteine | 9.16 | 7.666 |
| Tryptophan | 3.55 | 2.480 |
| ME/P | 12.70 | 17.100 |
| Feed pellet quality factor (FPQF) | Crumble N/A | 3.800 |

1USD = 6.77 TTD

*Price of feed varied according to feed type:

$$\text{Starter feed} = \frac{\$180\ \text{TTD}}{45\ \text{kg bag of feed}}$$

$$\text{Grower-finisher feed} = \frac{\$194\ \text{TTD}}{45\,\text{kg bag of feed}}$$

1US$ = 6.7993 TTD

Income over feed cost = VMP-FC

## RESULTS

**Feed intake and body weight:** Feed intake was measured as a function of time for the starter and grower phase using regression models. Table 2 shows the quadratic or second degree polynomial curve fitting for all treatment, respectively. Table 3 shows the effect of feed intake on live body weight (BW) for starter and grower phase. In all phases, a linear response was observed during the starter and grower phase. During starter phase bird fed 3 hrs post hatch gained 0.36g for every gram of starter consumed, compared to 0.03 g at 24 h, 0.43 g at 36 h and 0.47 g at 48 h, respectively. In contrast at the grower phase bird fed at 3 h post hatch gained 5.56 g, 0.19 g at 24 h, 0.20 g at 36 h and 0.47 at 48 h, respectively for every gram consumed. Cumulative feed intake, FCR and body weight at starter (0-21) and grower phase (22-63) is presented in Table 4.

**Economic implication of post hatch feed duration:** Table 5 summarized marginal physical product (MPP), feed cost (FC), value of marginal product (VMP) and margin over feed cost (MOFC) at the starter phase. There were no significant differences among treatments (p>0.05) except for feed cost (p = 0.021) where, feed cost was greater for birds fed at 3 h post hatch compared to those fed at 48 hrs post hatch.

In the grower phase (Table 6) no significant differences were observed for MPP, MVP, FC and MOFC. However, from 6th week the MOFC was negative for ducks fed at 3 and 24 h post-hatch. Whereas, from week seven to nine, MOFC was negative for birds fed at 36 and 48 hrs post hatch.

Figures 1 and 2 shows the relationship between the VMP and the FC at starter and grower phase for all treatment, respectively. During the starter phase ducks were fed at 3 h post-hatch; where feed cost was at 3.17 TTD kg$^{-1}$ the VMP = FC at 21 days. Grower feed cost was 4.50 TTD kg$^{-1}$ and the VMP was higher than FC at weeks four and five (Fig. 2). However, between weeks five and six the VMP = FC and continued to decline until week nine.

Table 2: Feed intake as a function of time at starter (0-21) and grower phase (22-63)

| Treatment (h) | Equations | $R^2$ | Adjusted $R^2$ | Aikie criterion | p-value |
|---|---|---|---|---|---|
| **Feed intake as a function of time (t)** | | | | | |
| **Starter phase** | | | | | |
| 1 (3 h) | $Y_{fi}$= 161.375 -201.583t+209.292t$^2$ | 0.922 | 0.913 | 73.701 | 0.024 |
| 2 (24 h) | $Y_{fi}$= -752.38+990.958t – 91.792 t$^2$ | 0.650 | 0.603 | 80.273 | 0.812 |
| 3 (36 h) | $Y_{fi}$= 128.24 -147.92t+162.08 t$^2$ | 0.981 | 0.978 | 76.906 | 0.000 |
| 4 (48 h) | Y= 84.21 -110.69 t+154.15t$^2$ | 0.978 | 0.975 | 79.322 | 0.005 |
| **Grower phase** | | | | | |
| 1 (3 h) | $Y_{fi}$= 876.972+621.598 t -19.2717t$^2$ | 0.863 | 0.854 | 176.664 | 0.274 |
| 2 (24 h) | $Y_{fi}$= -2093.05+650.03 t+109.64 t$^2$ | 0.989 | 0.988 | 135.601 | 0.000 |
| 3 (36 h) | $Y_{fi}$= -3121.53+1046.28 t+86.23 t$^2$ | 0.963 | 0.960 | 167.696 | 0.175 |
| 4 (48 h) | Yfi= 2611.11+816.66 t+102.90 t$^2$ | 0.996 | 0.996 | 128.779 | 0.000 |

t refers to time, $Y_{fi}$ = Feed intake

Table 3: Body weight as a function of feed intake at starter (0-21) and grower phase (22-63)

| Treatments (h) | Parameters | $R^2$ | Adjusted $R^2$ | Aikie criterion | p-value |
|---|---|---|---|---|---|
| **Body weight as a function of feed intake (FI)** | | | | | |
| **Starter phase** | | | | | |
| 1 (3 h) | $Y_{bw}$ = 64.233+0.356$FI_s$ | 0.741 | 0.725 | 88.063 | 0.000 |
| 2 (24 h) | $Y_{bw}$ = 137.11+0.0295$FI_s$ | 0.541 | 0.513 | 72.771 | 0.000 |
| 3 (36 h) | $Y_{bw}$ = 63.08+0.425$FI_s$ | 0.966 | 0.964 | 79.601 | 0.000 |
| 4 (48 h) | $Y_{bw}$ = 51.988+0.465$FI_s$ | 0.980 | 0.979 | 76.052 | 0.000 |
| **Grower phase** | | | | | |
| 1 (3 h) | $Y_{bw}$ = 4577.03+5.59947$FI_G$ | 0.828 | 0.823 | 159.981 | 0.000 |
| 2 (24 h) | $Y_{bw}$ = 882.86+0.191 $FI_G$ | 0.870 | 0.866 | 150.463 | 0.000 |
| 3 (36 h) | $Y_{bw}$ = 843.70+0.201 $FI_G$ | 0.880 | 0.877 | 147.827 | 0.000 |
| 4 (48 h) | $Y_{bw}$ = 950.7+0. 465$FI_G$ | 0.887 | 0.883 | 163.465 | 0.000 |

$FI_s$ and $FI_G$ refers to feed intake, $Y_{bw}$ = Body weight (BW)

Table 4: Cumulative feed intake, FCR and Body weight at starter (0-21) and grower phase (22-63)

| | Treatment (h) | | | | | |
|---|---|---|---|---|---|---|
| Parameters | 3 h | 24 h | 36 h | 48 h | SEM± | p-value |
| **0-21 days** | | | | | | |
| Cumulative feed intake (g) | 681.90 | 603.90 | 563.40 | 572.40 | 4.160 | 0.106 |
| FCR | 1.30 | 1.10 | 1.16 | 1.01 | 0.264 | 0.541 |
| BW (g) | 625.00 | 562.50 | 505.40 | 568.80 | 6.300 | 0.779 |
| **22-63 days** | | | | | | |
| Cumulative feed intake (g) | 6926.40[a] | 6443.00[a] | 5997.00[a] | 3381.40[b] | 11.170 | 0.000 |
| FCR | 3.01[a] | 2.77[a] | 2.60[a] | 1.46[b] | 0.217 | 0.000 |
| BW (g) | 2273.60 | 2324.60 | 22877.50 | 2316.30 | 4.710 | 0.839 |

Parameters [ab] with superscript in different rows indicate that differences between means are not significant (p>0.05)

## DISCUSSION

**Effect of post-hatch feed time on mule duck production:** The response to the duration of post hatch feeding in the present study regardless of the time of feeding showed a second degree polynomial curve for both the starter and grower phase. Similar results were obtained by Williams *et al.*[16] for broilers grown in the tropics. Further, a perusal of the literature did not indicate a similar study for ducks. However, results followed the law of diminishing return[10]. Thus, as the birds continue to grow they become progressively less efficient in feed utilization as increasing nutrients are shunted towards maintenance[17].

**Marginal physical product (MPP), Marginal value product (MVP) and margin over feed cost (MOFC):** The aim of local commercial Mule duck producers is to achieve optimum carcass weight at slaughter (63 days of age) and maximum profit. MPP (MPP, g gained $g^{-1}$ feed intake) defines feed conversion. To obtain VMP, MPP is multiplied by the price of body weight. Thus, VMP represents the added value (dollar) for ducks expected from each additional unit of feed intake[7]. The MPP, VMP and MOFC in the current study were not significantly affected by treatments (p>0.05) in both the starter and grower phases (Table 5 and 6). Production efficiency is commonly measured and compared as feed efficiency or feed conversion ratio which is reflected in body weight, MPP and VMP[9].

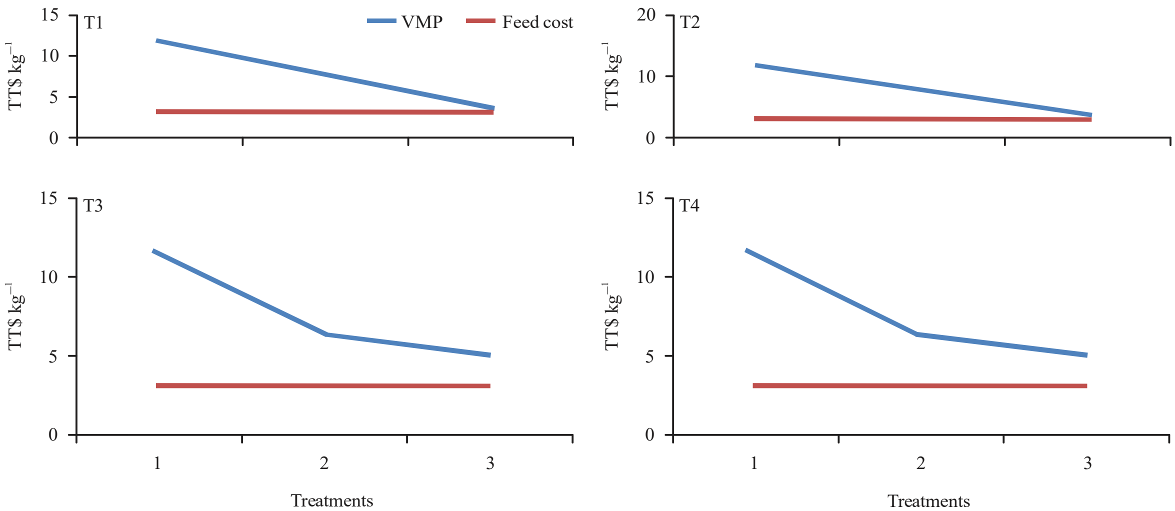


Fig. 1(a-d): Relationship between the VMP and FC at the starter stage for mule ducks fed at 3, 24, 36 and 48 h post hatch

Table 5: MPP, VMP, Feed cost and IOFC for Mule ducks during the starter phase

| | | Starter phase | | |
|---|---|---|---|---|
| | | Weeks | | |
| Parameters | Treatment | 1 | 2 | 3 |
| MPP | 1 | 0.761 | 0.571 | 1.022 |
| | 2 | 0.860 | 0.476 | 0.385 |
| | 3 | 0.860 | 0.476 | 0.385 |
| | 4 | 0.866 | 0.467 | 0.458 |
| SEM± | | 0.020 | 0.018 | 0.041 |
| p-value | | 0.547 | 0.419 | 0.528 |
| MVP | 1 | 10.271 | 7.702 | 13.790 |
| | 2 | 11.612 | 6.421 | 5.200 |
| | 3 | 11.612 | 6.421 | 5.200 |
| | 4 | 11.695 | 6.428 | 6.180 |
| SEM± | | 0.075 | 0.067 | 0.150 |
| p-value | | 0.547 | 0.419 | 0.528 |
| Feed cost | 1 | 0.729[a] | 2.566 | 6.207 |
| | 2 | 0.633[ab] | 2.600 | 5.329 |
| | 3 | 0.614[ab] | 2.072 | 4.927 |
| | 4 | 0.550[b] | 2.066 | 4.911 |
| SEM ± | | 0.017 | 0.037 | 0.058 |
| p-value | | 0.021 | 0.089 | 0.242 |
| IOFC | 1 | 3.350 | 1.000 | 3.130 |
| | 2 | 3.250 | 1.740 | 2.650 |
| | 3 | 4.460 | 1.900 | 2.700 |
| | 4 | 4.300 | 1.810 | 3.120 |
| SEM ± | | 0.710 | 0.410 | 0.720 |
| p-value | | 0.767 | 0.268 | 0.980 |

Parameters[ab] with superscript in different rows indicate that differences between means are not significant (p>0.05)

During the starter phase (weeks 1-3) MPP was at its highest in week one but decreased as the ducks age. This result agrees with some previous studies, which stated that even though MPP was declining but it was still positive thus indicating that body weight is increasing but at a slower rate[16].

In the grower phase (weeks 6-9) the MOFC was negative; Fig. 2 shows the relationship between the VMP and FC. The negative value indicates that addition of every gram of grower feed decreased the weight gain of the ducks and therefore feeding beyond this point becomes unprofitable as production will now be operating in the third stage of production[5].

In the current study, the VMP (TT$4.50) for the current grower phase (between week 5 and 6) suggested that the MOFC was about to be maximized and ducks should be slaughtered. However, the market requires a bird weighing approximately 3.0 kg which is obtained between 63-70 days locally[2]. This suggests that different feeding program for local Mule duck production should be examined rather than the program designed for temperate environment[6].

Ducks fed at 3 h post-hatch showed higher values for MPP and VMP though not statistically significant during the starter and finisher feeding phases. However, these birds consumed more feed at both the starter and grower phases (Table 2). Figure 2 shows that during the grower phase (between week five and six) the VMP = FC; thus, indicating that beyond this point producers should not further invest on feed.

According to Rushton[9] when added feed cost becomes equal to added meat value, birds should be slaughtered before cost exceeds returns. Additionally, Debertin[10] stated that when VMP = FC it represents the point at which the amount of input maximizes the profits.

During the grower feeding phase (Fig. 2; when the VMP = \$1.00TTD kg$^{-1}$), if ducks are to be reared upto 9 weeks (63 Days) feed type should be changed (from grower to finisher type) after 5 weeks. This should be done in order to ensure that a profit is made at the time of harvesting ducks (9 weeks). This change in feed type should not exceed \$1.00TTD kg$^{-1}$ (1TTD = US\$6.7993).

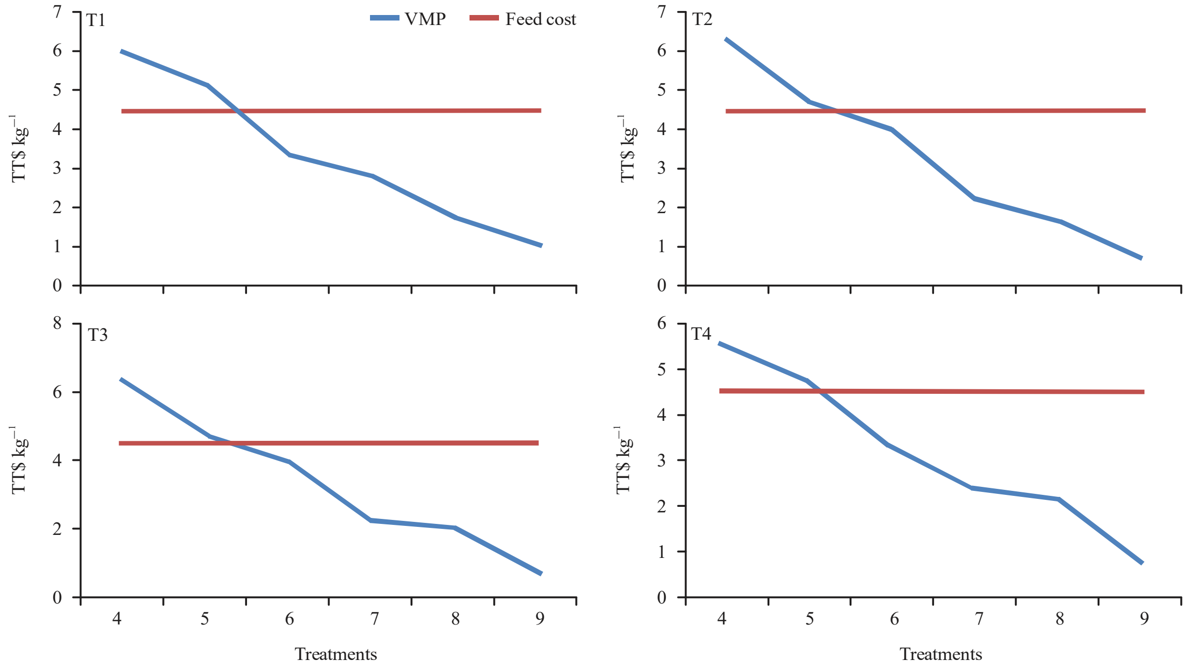


Fig. 2(a-d): Relationship between the VMP and FC at the grower stage for mule ducks fed at 3, 24, 36 and 48 hrs post-hatch

Table 6: MPP, VMP Feed cost and IOFC for Mule ducks during the grower phase

| | | Grower phase | | | | | |
|---|---|---|---|---|---|---|---|
| | | Weeks | | | | | |
| Parameter | Treatment | 4 | 5 | 6 | 7 | 8 | 9 |
| MPP | 1 | 0.447[a] | 0.385 | 0.251 | 0.209 | 0.129 | 0.079 |
| | 2 | 0.469 | 0.353 | 0.291 | 0.165 | 0.124 | 0.054 |
| | 3 | 0.469 | 0.353 | 0.291 | 0.165 | 0.124 | 0.054 |
| | 4 | 0.414 | 0.356 | 0.247 | 0.177 | 0.159 | 0.056[a] |
| SEM± | | 0.019 | 0.014 | 0.016 | 0.0130 | 0.0171 | 0.0013 |
| p-value | | 0.806 | 0.816 | 0.630 | 0.453 | 0.901 | 0.828 |
| MVP | 1 | 6.036 | 5.192 | 3.390 | 2.830 | 1.740 | 1.072 |
| | 2 | 6.330 | 4.760 | 3.930 | 2.220 | 1.671 | 0.726 |
| | 3 | 6.330 | 4.760 | 3.930 | 2.220 | 1.671 | 0.726 |
| | 4 | 5.591 | 4.800 | 3.330 | 2.380 | 2.140 | 0.756 |
| SEM± | | 0.068 | 0.052 | 0.059 | 0.048 | 0.063 | 0.055 |
| p-value | | 0.806 | 0.816 | 0.631 | 0.453 | 0.901 | 0.828 |
| Feed cost | 1 | 10.963 | 18.117 | 27.105 | 37.183 | 47.944 | 56.526 |
| | 2 | 10.590 | 18.361 | 28.400 | 41.213 | 56.574 | 71.567 |
| | 3 | 9.866 | 16.263 | 24.326 | 34.266 | 43.965 | 52.040 |
| | 4 | 9.361 | 15.939 | 23.755 | 33.149 | 43.258 | 51.823 |
| SEM± | | 0.084 | 0.111 | 0.140 | 0.168 | 0.200 | 0.234 |
| p-value | | 0.677 | 0.734 | 0.699 | 0.682 | 0.603 | 0.560 |
| IOFC | 1 | 3.350 | 5.670 | -0.510 | -6.200 | -12.280 | -19.140 |
| | 2 | 3.250 | 2.780 | -2.010 | -9.800 | -21.100 | -36.000 |
| | 3 | 4.460 | 5.180 | 4.470 | -0.720 | -6.730 | -14.090 |
| | 4 | 4.300 | 5.080 | 3.100 | -1.540 | -7.030 | -14.640 |
| SEM± | | 0.710 | 1.010 | 1.320 | 1.650 | 1.970 | 2.410 |
| p-value | | 0.767 | 0.764 | 0.546 | 0.632 | 0.554 | 0.532 |

Cumulative feed intake, FCR and body weight of mule ducks at both the starter (0-21 days) and grower (22-63 days). Results showed that at the starter phase no significant differences were observed among treatments for all parameters (p = 0.106, p = 0.541, p= 0.779; respectively). While at the grower phase significant differences was noted among treatments for the cumulative feed intake and FCR (p = 0.00)

Although minimize the feed cost is useful and important but returns must also be considered in order to determine the most profitable combination of feed ingredients for the ration[9]. In the current study, the theoretical relationship indicated that if finisher feed is offered from six to nine weeks then the value of the feed ingredient should not exceed \$1.00TT kg$^{-1}$. However, Thirumalaisamy *et al*.[3] suggested that feed cost must be reduced very carefully as this may affect the overall profit by decreasing the growth performance of the bird. Currently, in the poultry industry, model used for feed formulation consider the combination of ingredients that meet nutrient requirement at the least cost[3].

However, for ducks, a critical aspect of dietary energy and protein content (in particular the ME/P ratio) must be considered for growth performance and feed efficiency[18] that impacts the VMP.

ME/P ratio for duck feed was 12.7 for starter and 17.1 for grower phase (Table 1). However, NRC[13] recommendations for ducks were 13 for starter and 18.8 for grower phase. It is therefore possible that the ratio (ME:P) and post hatch feeding time also influenced the MOFC. MOFC was -0.51 and -2.01 at 6th weeks for those birds fed at 3 and 24 h post-hatch during the grower phase whereas MOFC became negative at 7th week for those birds fed at 36 and 48 hrs post hatch. A perusal of the literature has shown that no study was conducted in this area on ducks for comparison.

## CONCLUSION

Starter diet can be fed up to 21 days without affecting the live weight and economic performance of ducks fed at 3, 24, 36 and 48 h post-hatch. If Mule ducks are to be reared upto 63 days (9 weeks) a change in feed type from grower to finisher type should occur after 35 days (5 weeks). This change in feed type should not exceed \$1.00TTD kg$^{-1}$ in order to ensure that there is a profit.

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