Effect of Early Post-Hatch Feeding Time on Growth and Carcass Performance of Mule Ducks Reared Intensively in the Humid Tropics

ABSTRACT

A prolonged period without feed access negatively impacts the growth and development of poultry. This study evaluated the effect of early post-hatch feeding times on the growth and carcass performance of Mule ducks reared intensively in the tropics. A total of 48 Mule ducklings were obtained from a local hatchery and assigned in a completely randomized design to 4 treatments based on 4 feeding regimes, (T) as follows: T1 3hrs, T2 24hrs, T3 36hrs and T4 48hrs post-hatch. On day 1 the ducklings were individually weighed, followed by weekly weighing until harvest at 63 days. Feed and feed refusal was measured daily for a period of 63 days. At harvest the body weight at slaughter, eviscerated and hot carcass weight, as well as the initial pH and pH24 of the breast, leg, and thigh quarters was evaluated. Weights of the organs of the gastrointestinal tract were then taken. The feed conversion ratio (FCR), feed intake and meat: skin: bone ratio was calculated. At 0-7 days cumulative feed intake and FCR was influenced by treatment (p=0.022, p=0.026; respectively). Body weight at slaughter ranged from 2969-3382.5g. Treatment did not affect the weights of the bone, fat, muscle and skin, of the breast quarter (p=0.698, p=0.893, p=0.940; respectively). However, weight of the bone for the leg and thigh quarter differed among treatments. A lower pH24 was observed for both breast and leg and thigh quarters. The study suggests that early post-hatch feeding at 3-48hrs does not affect the performance of Mule ducks.

INTRODUCTION

In Trinidad and Tobago, duck production is generally done on a subsistence level with farmers rearing ducks in their backyards. Further, there has been an increase in the demand for duck meat partly due to the influx of Chinese restaurants, as well as an improvement in housing development and technology. This has led to the expansion of the sector towards more commercial semi-intensive and intensive operations (Lallo & Ramraj, 2008). Moreover, the move towards inclusion of ducks into supermarket chains has led to a demand for improved quality carcasses (Lallo & Ramraj, 2008). Additionally specialization within the industry has seen the emergence of hatchery operations as well as increases in the number of grow-out operations (Lallo et al., 2007). However, there is currently a lag time in the movement of birds from the hatchery to the grow-out operations. This increase in holding time post-hatch without access to feed has been said to have a negative effect on the growth and development of poultry (Noy & Sklan, 2001). One major disadvantage of delayed feeding is body weight loss due to a decrease in the weights of tissues and organs (Nir & Levanan, 1993).

Early post-hatch feeding has been noted to stimulate the growth of the gastrointestinal tract and its absorptive capacity (Saki, 2005);
thereby significantly affecting growth, feed efficiency,  
uniformity, carcass yield and cost of production (Saki,  
2004). A perusal of the literature has shown that this  
same practice is not studied in Mule ducks. In light of  
this, this study sought to evaluate the effect of early  
post-hatch feeding times on the growth and carcass  
performance of Mule ducks reared intensively in the  
tropics.

MATERIALS AND METHODS

Location and Climate

Trinidad is located within the humid tropics at 10  
1/2° North latitude and 6 1/2° West longitude. Daily  
temperatures range between 24.1 - 36.15 °C and  
average humidity of 80.21. There are two seasons: a  
dry season from January to May and a rainy season from  
June to December. The experiment was conducted  
during the wet 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 north Trinidad.

Animals and Experimental Design

A total of 48 Mule ducklings were obtained from a  
local hatchery and assigned in a completely randomized  
design to four treatment groups based on four feeding  
regimes, (T) as follows: T1 3h, T2 24h, T3 36h and  
T4 48h post-hatch. Each treatment group comprised  
of 6 replicates with 2 ducklings each. On Day 1 the  
ducklings were individually weighed, followed by  
weekly weighing until 63 days. Each treatment was  
replicated six times with a total of 2 ducklings per  
replicate (12 ducklings per treatment). They were  
raised in an open sided naturally ventilated house in  
cages of dimension: Length 122cm x Width 61cm and  
a stocking density of 2 birds/m2 was used. Treatment  
1 received both water and feed 3hrs post-hatch while  
the other treatments received no feed until 24, 36 and  
48hrs, post-hatch, respectively. Feed offered was given  
according to National Research Council standards  
(NRC, 1994) and refusal was measured daily in order  
to determine feed intake while water was given ad  
libitum. No vaccination was done in accordance with  
local production practices.

Diet

A commercial duck ration formulated primarily from  
soybean and corn was weighed and fed to the ducks  
once a day. Table 1 gives chemical composition of diet  
fed. Ducklings were fed starter ration for 21 days and  
from 22 days the ducks were fed a grower ration until  
63 days.

Animal Management

The mean (± SEM) initial weights of the ducklings  
for each treatment were: T1: 51.83g ±3.98, T2:  
51.17g±7.14, T3: 51.92g±.47 and T4: 51.42g±3.75.  
The ducks were observed on a daily basis for problems  
with pests and diseases. At 7 days the ducklings were  
weighed using an electronic scale (OHAUS IR SENSOR).  
This procedure was repeated weekly until harvest  
age (63 days). Feed conversion ratio (FCR) during the  
respective weeks and the overall period was calculated  
as the ratio between units feed intake and unit weight  
gain.

Carcass Evaluation

At the end of the experiment (63 days), the ducks  
from each treatment were weighed and labeled for  
subsequent identification. This weight was recorded as  
the live weight/ body weight at slaughter. The ducks  
were then euthanized according to the APA 2000  
Ethics Code using the cervical dislocation. The feathers  
and the internal organs were then removed and the  
eviscerated carcass weight was taken. The weight of  
the liver, gizzard, proventriculus and small and large  
intestines were taken and recorded. The head and feet

Table 1 – Composition of Starter and Grower Diet.

| Ingredients (g/kg-1 DM) | Starter | Grower |
|------------------------|---------|--------|
| Soyabean Meal (470g CPkg-1 DM) | 415.2 | 251.2 |
| Ground corn | 356.4 | 548.1 |
| Rice Bran | 80.0 | 100.0 |
| Broken Rice | 60.6 | 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 | 893 |
| ME (kcal/1 DM) | 2.850 | 3.038 |
| Crude Protein* | 224 | 178 |
| NDF* | 164 | 330 |
| Ca | 10.5 | 10.5 |
| Available P | 4.6 | 4.0 |
| Ca: Available P | 2.3 | 2.6 |
| Lysine | 15.0 | 10.6 |
| Methionine | 4.66 | 4.05 |
| Methionine + Cysteine | 9.16 | 7.666 |
| Tryptophan | 3.55 | 2.48 |
| ME/P | 12.7 | 17.1 |

Feed Pellet Quality Factor (FPQF) Crumble 3.8
of the ducks were removed and the weights of the carcasses were taken, this weight was referred to as the hot carcass weight. Using a handheld pH meat meter (Hannah, Model HI99163) the pH of the breast, leg and thigh of the carcasses was taken and recorded. This procedure was repeated at 24 hours (pH 24h). The carcasses were then physically separated into wings, breasts, leg and thigh quarters and neck and back. Each component was weighed and recorded. The skin and subcutaneous fat was removed from the muscles and the muscles removed from the bone for each component. They were then weighed and recorded in order to determine a meat:skin:bone ratio.

Statistical Analysis and Calculation
The data was subjected to a one way Analysis of Variance (ANOVA) and mean separation (Fisher’s pair-wise comparison) was done using Minitab Release 18 for Windows (Minitab 2017).

RESULTS

Growth Performance
Table 2 below shows the effects of early post-hatch feeding on the performance of Mule ducks reared intensively at the University Field Station. At 0-7 days cumulative feed intake and feed conversion was affected by treatment (p=0.022), (p=0.026); respectively. Cumulative feed intake was observed to be the highest in the group fed at 36hrs post-hatch and the lowest in those fed at 48hrs. Whereas, at 0-21 and 0-63 days post-hatch feeding times did not impact on the body weight, cumulative feed intake and FCR.

| Treatment (hours) | Body weight (g) | Cumulative Feed Intake (g) | Feed conversion |
|-------------------|-----------------|---------------------------|-----------------|
| 0-7 days          |                 |                           |                 |
| 3 hours           | 119.17 ±        | 84.50 ±                   | 0.71 ±          |
| 24 hours          | 129.17 ±        | 73.42 ±                   | 0.57 ±          |
| 36 hours          | 122.50 ±        | 71.25 ±                   | 0.59 ±          |
| 48 hours          | 119.58 ±        | 63.88 ±                   | 0.55 ±          |
| ±SEM              | 0.804           | 0.646                     | 0.611           |
| p-value           | 0.694           | 0.022                     | 0.026           |
| 0-21 days         |                 |                           |                 |
| 3 hours           | 477.1 ±         | 681.9 ±                   | 1.53 ±          |
| 24 hours          | 562.5 ±         | 603.9 ±                   | 1.10 ±          |
| 36 hours          | 505.4 ±         | 563.4 ±                   | 1.16 ±          |
| 48 hours          | 568.8 ±         | 572.4 ±                   | 1.01 ±          |
| ±SEM              | 0.122           | 1.861                     | 0.115           |
| p-value           | 0.375           | 0.106                     | 0.065           |
| 0-63 days         |                 |                           |                 |
| 3 hours           | 3102.9 ±        | 6500 ±                    | 2.11 ±          |
| 24 hours          | 3039 ±          | 6589 ±                    | 2.27 ±          |
| 36 hours          | 3077 ±          | 6045 ±                    | 1.96 ±          |
| 48 hours          | 3051.5 ±        | 5774.8 ±                  | 1.90 ±          |
| ±SEM              | 7.25            | 16.11                     | 0.355           |
| p-value           | 0.975           | 0.669                     | 0.748           |

*Rows with different superscript letters indicate differences between means of treatments (p<0.05).

Carcass Evaluation
Table 3 below shows the effect of four different post-hatch feeding times on the carcass performance of Mule ducks. At 24hrs post slaughter only the body weight at slaughter was affected by treatment. No significant difference (p>0.05) was observed between treatments for carcass components, organ weights of the gastrointestinal tract (gizzard, proventriculus, and liver) and intestines. However, post-hatch feeding times were noted to influence the weight of the whole wing of Mule ducks.

Physically-Separated Components
Table 4 shows the effect of four different post-hatch feeding times on the physically-separated components of the carcass of Mule ducks reared to 63 days. Significant differences were noted among treatments (p=0.005) on the wing portion (g/ 100g eviscerated carcass weight) but there was no significant difference for the skin, fat, meat and bone of the breast among the treatments. The bone of the leg and thigh quarter differed (p=0.000) between treatment groups. No difference was observed among treatment groups.
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Table 3 – The effect of early post-hatch feeding on the carcass performance of Mule ducks grown to 63 days.

| Weights (g) | Treatment | ± SEM | p-value |
|-------------|-----------|-------|---------|
| Post Hatch Feeding Time | 1 (3hrs) 2 (24hrs) 3 (36hrs) 4 (48hrs) |
| Body weight at slaughter (g) | 3342.2ab 2969a 3382.5a 3260.8ab |
| Evaccered carcass (g) | 2366.7a 2182a 2456.7a 2374.2a |
| Hot carcass weight (g) | 2280.8a 2129a 2358.3a 2301.7a |
| Chilled carcass weight at 24 hours (g) | 2258.3a 2093a 2360a 2294.2a |
| Whole wing (g) | 302.5a 298.33a 394.2a 314.17a |
| Whole breast (g) | 588.3a 615a 620.8a 659.2a |
| Whole Leg (g) Quarters | 427.5a 383.3a 465.8a 421.7a |
| Neck and back (g) | 867.5a 805a 895a 848.3a |
| Proventriculus (g) | 10a 10a 6.67a 9.167a |
| Gizzard (g) | 63.6a 62.50a 67.5a 72.5a |
| Liver (g) | 45.83a 46.67a 46.67a 45a |
| Intestines (large and small) (g) | 107.50a 98.33a 87.50a 105.8a |
| Dressing percentage (g/kg) | 67.58a 70.489a 69.7a 70.3a |

The carcass weight was inclusive of the neck.

Table 4 – The effect of early post-hatch feeding on physically-separated components of breast and leg quarters of Mule ducks at 63 days.

| Weights (g) | Treatment | ± SEM | p-value |
|-------------|-----------|-------|---------|
| Post-Hatch Feeding times | 1 2 3 4 |
| Breast: Skin + fat (g) | 107.5a 100.8a 98.3a 108.3a |
| Meat (g) | 355.8a 335.8a 358.3a 347.5a |
| Bone (g) | 134.2a 142.50a 144.17a 150a |
| Leg + Thigh Quarter: Skin + fat (g) | 108.3a 78.3a 78.3a 97.5a |
| Meat (g) | 239.17a 225a 238.3a 249.17a |
| Bone (g) | 95a 75b 81.67b 75.83b |

ab Rows with different superscript letters indicate differences between means of treatments (p<0.05).

for skin and fat, meat and bone of the leg and thigh quarter. It was also observed that the breast yield, leg and thigh quarter, neck and back did not differ significantly among treatments (as seen in Table 5). The organs of the gastrointestinal tract: proventriculus, gizzard, liver and intestines as g/100g of the evacuated carcass weights were not different among treatments (p>0.05).

Table 5 – The effect of post hatch feeding on the carcass yield of Mule ducks.

| Weights (g) | Treatment | ± SEM | p-value |
|-------------|-----------|-------|---------|
| BreastYield (g/100g EVC) | 17.61a 20.75a 18.40a 20.18a |
| LegQuarter (g/100g EVC) | 12.80a 12.90a 13.74a 2.94a |
| Wing g/100g EVC | 9.08a 10.12a 11.62a 9.64a |
| Neck&Back g/100g EVC | 25.97a 26.99a 26.50a 25.99a |
| Prov g/100g EVC | 0.30a 0.35a 0.20a 0.28a |
| Gizzard g/100g EVC | 1.91a 2.12a 1.99a 2.23a |
| Liver g/100g EVC | 1.38a 1.58a 1.38a 1.38a |
| Intestines g/100g EVC | 3.22a 3.36a 2.59a 3.25a |

ab Rows with different superscript letters indicate differences between means of treatments (p<0.05).

The effect of four different post-hatch feeding times on the pH for breast and leg quarters of Mule is illustrated in Table 6. The pH of the breast for hot carcass (p=0.017) differed among treatments. However, post-hatch feeding times did not affect the pH of the leg quarters. No significant difference occurred among treatments of the pH of the breast and leg quarters of the Mule ducks at 24hrs.
**DISCUSSION**

**Growth Performance**

The results showed that at 0-7, 0-21 and 0-63 days post-hatch feeding times had no effect on the body weight of ducks for this study (See Table 2). Contrastingly, Bhanja et al. (2009) reported that the body weight at 0-7, 0-21 and 0-35 days of broiler chicks was affected by the time of post-hatch feeding. However, ducks used in this study were grown to 63 days while broilers were grown to 35 days; thus the difference in market age may have attributed to the contrasting results. Body weight for ducks at 0-7 days ranged from 119.17 - 129.17g which was slightly similar to the range observed for broiler chicks (106-138g) at 0-7 days (Bhanja et al. 2009). Garden (2008) reported that the 7 day weight of broilers should be approximately 4-5 times the day old broiler chick’s weight. Even though the 0-7 days weight of Mule ducklings were similar to broilers, the ducklings were observed to be less than 4.5 - 5 times the placement weight. This may be attributable to the difference in the placement weight of species.

At 0-21 and 0-63 days the body weight of ducks from this study was within a range of 477.1-568.8g and 3051.5-3102.9g; respectively. These results were incongruent to body weights of different strains of Pekin ducks and Muscovy at 0-21 days (1063, 1146 and 1118g; respectively) but similar to the Mule and Muscovy duck (3100 and 2378; respectively) at 0-7 days (Bhanja et al. 2009). Garden (2008) reported that the 7 day weight of broilers should be approximately 4-5 times the day old broiler chick’s weight. Even though the 0-7 days weight of Mule ducklings were similar to broilers, the ducklings were observed to be less than 4.5 - 5 times the placement weight. This may be attributable to the difference in the placement weight of species.

### Table 6 – The effect of post-hatch feeding on the pH of Breast and Leg Quarters of Mule ducks.

| pH                  | Treatment ± SEM | p-value |
|---------------------|-----------------|---------|
| Breast pH value     |                 |         |
| 1(3h)               | 5.52a           | 0.05    |
| 2(24h)              | 5.45a           | 0.728   |
| 3(126h)             | 5.67a           |         |
| 4(48h)              | 5.43a           | 0.017   |
| Leg Quarter pH value|                 |         |
| 1(3h)               | 5.84a           | 0.07    |
| 2(24h)              | 5.77a           | 0.261   |
| 3(126h)             | 5.81a           |         |
| 4(48h)              | 5.62a           |         |
| Breast pH3h         |                 |         |
| 1(3h)               | 4.33a           | 0.06    |
| 2(24h)              | 4.29a           | 0.728   |
| 3(126h)             | 4.39a           |         |
| 4(48h)              | 4.31a           |         |
| Leg Quarter pH3h    |                 |         |
| 1(3h)               | 4.97a           | 0.10    |
| 2(24h)              | 5.04a           | 0.468   |
| 3(126h)             | 4.93a           |         |
| 4(48h)              | 4.70a           |         |

*Rows with different superscript letters indicate differences between means of treatments (p<0.05).*

The results showed that at 0-7 days post-hatch feeding times had no effect on the body weight of ducks for this study (See Table 2). Contrastingly, Bhanja et al. (2009) reported that the body weight at 0-7, 0-21 and 0-35 days of broiler chicks was affected by the time of post-hatch feeding. However, ducks used in this study were grown to 63 days while broilers were grown to 35 days; thus the difference in market age may have attributed to the contrasting results. Body weight for ducks at 0-7 days ranged from 119.17 - 129.17g which was slightly similar to the range observed for broiler chicks (106-138g) at 0-7 days (Bhanja et al. 2009). Garden (2008) reported that the 7 day weight of broilers should be approximately 4-5 times the day old broiler chick’s weight. Even though the 0-7 days weight of Mule ducklings were similar to broilers, the ducklings were observed to be less than 4.5 - 5 times the placement weight. This may be attributable to the difference in the placement weight of species.

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and body weight gain in the neonatal period and beyond of birds (Dibner et al., 1998; Noy & Sklan, 1998; Viera & Moran, 1999).

The results showed that at 0-7 days cumulative feed intake differed significantly among treatments (p=0.022). At 0-63 days, cumulative feed intake of ducks (5774.8-6589g) was lower than that of Mule strains and Muscovy (10726 and 7263g; respectively) grown to 95 days (Lallo et al., 2007). Cumulative feed intake was higher in the group of ducks fed at 3hrs post-hatch in comparison to those fed at 24, 36 and 48hrs. Similar to the findings of this study, Obun & Osaguona (2013) reported that at 0-7 days post-hatch feeding times significantly affected the cumulative feed intake of broiler chicks.

At 0-7 days there was no difference noted among treatments for the feed conversion of ducks (p=0.026). Contrastingly, Ganja et al., (2015) found that the feed conversion ratio (FCR) of birds fed at 6hrs post-hatch were significantly superior (p<0.05) to those with access to feed at 12 and 18hrs. The feed conversion at 0-7 days for ducks from this study ranged from 0.55 to 0.71. Concomitant to the findings of this present study, Bhanja et al. (2009) reported that at 0-7 days broiler chicks feed conversion ratio ranged from 0.86-0.96. The FCR when compared to other species of ducks at 0-21 days was lower (1.01-1.53) than local (2.00) and international (2.21) Pekin strain and Mule strain from Canada (2.29) (Lallo & Ramraj, 2008). However, similar observations were made at 0-63 days in which the FCR of ducks in this study was slightly lower than the Mule and Muscovy ducks used by Lallo et al. (2007). The ducks all had a FCR ranging from 1.90 – 2.27 at 0-63 days. The strain of ducks used was the Mulard Hytop 82 which was imported from Canada, while the strains used by Lallo & Ramraj (2008) and Lallo et al. (2007) came from Maple Leaf farm USA, Les Simetin of Canada, Trinidad and Tobago and Grimaud Freres of France. Muscovy and their crosses generally utilize feed more efficiently than White Pekin crosses at all ages; this may further explain the differences in FCR observed (Hetzel, 1983). The relative performance of ducks is
dependent upon both strain and environment (Scott & Dean, 1991). Cumulative feed intake and FCR of the ducks was found to be higher in the group that was fed at 3hrs in comparison to those fed at 24, 36 and 48hrs. This finding highlighted the need for an economic evaluation to be done in order to further explain the significance of such discovery.

**Carcass Evaluation**

The body weight of the Mule ducks at slaughter was significantly \( (p=0.027) \) affected by post-hatch feeding (See Table 3). Further, the group of ducks that were exposed to feed at 36hrs post-hatch showed the highest body weight at slaughter (3382.5g) in comparison to those that were fed at 3, 24 and 48hrs. This result supports the claim by Cateel et al. (1994); Hager & Beane (1983); Noy & Sklan (1999b) that one of the major consequences of delayed access to feed is body weight loss. However, the results were not in keeping with those found for broilers (Obun & Osaguona, 2013). The market age used for broilers was 42 days while 63 days was the age at which ducks from this study was harvested; thus giving the ducks more time to compensate in growth (Scott & Dean, 1991). This difference in grow-out age between species may have contributed to the contrast between the results observed.

The ducks fed at 36hrs post-hatch gained 1.2, 12.2 and 3.6% more weight than those deprived of feed for 3, 24 and 48hrs. This result was not in agreement with Gonzales et al. (2003) for broiler chicks; in which broilers were 8-10% heavier than those held without feed or given water only This result observed may be attributable to the level of growth recovery after a period of feed deprivation (Gonzales et al., 2003). At 0-63 days, body weight of ducks fed at 3, 24, 36 and 48hrs post-hatch was not affected by the feeding times; however the difference between body weights at slaughter would suggest that there was some compensatory growth (Scott & Dean, 1991). At 63 days, the ducks observed all had body weights at slaughter ranging from 2969-3382.5g and were not similar to that reported for Mule and GrimaudFreres Strain at 95 days in which the body weight at slaughter was 3680, 3775 and 3605g (Lallo et al. (2007). This difference observed may be attributed to the strain of ducks used as well as the market age. However, the body weights at slaughter of ducks from this study was closer to Mule strains from Canada and Maple Leaf Farm USA (3078 and 2987; respectively) which were harvested at 70 days.

Eviscerated carcass weight of the Mule ducks ranged from 2182 to 2456.7g and showed no significant differences among treatments \( (p=0.095) \). This result was not in keeping with the weight of eviscerated carcass obtained for Mule and both local and imported Pekin strains harvested at 70 and 49 days (Lallo et al. (2007). However, at the time the eviscerated carcass weight was taken the neck of the ducks were still attached which may have contributed to the differences in weights observed by Lallo et al. (2007) for Mule and Pekin duck strains.

Post-hatch feeding times did not significantly influence the breast yield of the ducks observed. This result showed disagreement with Halevy et al., for broilers (2003) in which delayed feeding caused a decline in breast muscle weight through to market age. The breast yield of Mule ducks for this study fell within a range of 588.3-659.2g for all treatment groups (3, 24, 36, 48 hrs). Further it was seen that the breast meat yield of the group fed at 48 hrs post-hatch had the highest weight 659.2g. This result did not support the claim by Noy & Sklan (1998); Careghi et al. (2005); Tweed (2005) for broilers. However, the difference among treatments observed may be correlated to the pH value. Since the pH influences the drip loss (water holding capacity) and impacts on the overall weight of the breast yield (Van Laack, 2000).

The weight of the wing for the ducks ranged from 298.33-394.2g. These weights were similar to the Muscovy and Pekin ducks but different to the weights of the wing of Mule ducks grown to 95 days (Lallo et al., 2007).

Results of the study showed that post-hatch feeding times (3, 24, 36, 48hrs) did not have an effect on the weights of the proventriculus \( (p=0.421) \), gizzard \( (p=0.604) \), liver \( (p=0.953) \), and intestines \( (p=0.075) \). This result supports the claim by El-Husseiny et al. (2008). Similarly, Petek et al. (2007) reported that post-hatch feeding times \( (0, 18, 36hrs) \) had no significant impact on the parameters of liver and gizzard of broilers.

Post-hatch feeding time did not significantly impact on the weight of the intestines for Mule ducks; however this result was not similar to results obtained for broilers harvested at 42 days (Abed et al., 2011). The intestine of the ducks observed at 63 days (Lallo et al. 2007) was not in keeping with those found for broilers harvested at 70 days (Abed et al., 2011). The intestine of the ducks observed at 63 days (Lallo et al. 2007) was not in keeping with those found for broilers harvested at 70 days (Abed et al., 2011).
compared to both broilers and turkeys were found to be closer to that of broilers (71%) than turkeys (79%) (Schweighofer, 2011, sourced from Kendall, 2001). Similarly the dressing percentage of ducks from this study fell within similar range as other breeds of ducks in Nigeria (Omojola, 2007).

**Physically-Separated Components**

Carcass composition differs in the weight, fat content, muscle and bone of various species (Irshad et al., 2012). Moreover, procedures used to measure carcass composition in ducks have varied among different researchers (Wilson, 1975; Veltman & Sharlin, 1981) making it difficult to compare results. The skin and fat, meat and bone in the breast yield were not significantly affected by post-hatch feeding times in this study (p=0.940, p=0.893, p=0.698). The breast yield for ducks (See Table 4) (g/100g EVC) ranged from 17.61 to 20.75 g and was found to be lower than strains of Mule ducks grown to 70 days (Lallo & Ramraj, 2008). Likewise, the leg and thigh yields of Mule ducks ranged from 12.80, 12.90, 13.74, 12.94g/100g EVC for treatments 1, 2, 3 and 4; respectively. These values fell outside the range observed by Lallo & Ramraj (2008) for two different strains of Mule ducks (17.7 and 18.7 100g EVC). This difference may be attributable to the difference in harvest age which was 70 days for ducks from Lallo & Ramraj (2008) and 63 days for Mule ducks.

Various breeds and strains of ducks show differences in carcass composition; this species, like the goose and swine, is normally fat. Ducks normally deposit thick layers of subcutaneous and abdominal fat. The ducks under observation all had skin and fat (as grams per 100g of the breast yield) values ranging from 15.8 to 18.3 and 16.8 to 25.3 (as g/100g of the leg and thigh yield) for the leg and thigh quarter, respectively. The skin and fat for both breast and leg and thigh yield were not different to that reported for Mule strains of Canada and Maple leaf farm USA (Lallo & Ramraj, 2008).

The carcass tissue composition and meat quality of drakes and ducks of A44 strain reared to 9 weeks revealed that the meat: fat ratio was 1.01:1, meat: bone ratio 1.07:1 and the fat: bone ratio was 1.07:1 Witak (2008). However, the meat: skin: bone ratio of the breast yield for ducks from this present study was found to be 1:5:4, 1:6:4, 1:6:4, 1:6:4 for Treatments 1, 2, 3 and 4; respectively. Whereas, for the leg and thigh quarter the ratio for T1, T2, T3 and T4 were 1:3:4, 1:4:5, 1:5:5 and 1:4:5; respectively. These results were slightly different to Witak (2008). As animals mature, both an increase of muscle to bone and fat to muscle ratio and a decrease in muscle growth rate occurs (Lawrie, 1998). This explanation may probably be the reason for the ratio observed for ducks from this study. However, a higher ratio is better since it equates to more saleable lean meat and better carcass conformation (Irshad et al., 2012).

**pH**

pH and the ultimate pH (pH$_{24}$) are extremely important indicative parameters of meat quality since there is a correlation between pH value and poultry meat quality (Ristic & Freudenreich, 2006). The major attributes which define the quality of poultry and other types of meats are appearance, texture, juiciness, flavor and functionality all of which are influenced by pH (Glamoclija et al., 2015). In this study the pH of the breast quarter of ducks (hot carcass) ranged from 5.45-5.67 (See Table 5) and was slightly similar to the range of 5.6-5.9 for broilers (Rose, 1997). This study also found that the pH of the breast quarter differed among the treatment (p=0.017) with ducks belonging to the group fed at 36hrs showing the highest pH. The differences in pH observed may be explained by Van Laack & Kauffman (1999); Van Laack et al. (2000). These authors stated that even though muscles may have the same lactate concentration these muscles may have different pH and is determined by the glycogen concentration.

The pH of the leg and thigh quarter of ducks in this study all fell within the range of 5.62-5.8; however when compared to broilers the results were not similar. Since the pH value can range from 5.2 to 7.0 for poultry meat and is influenced by both breed lines and species (Baeea, 1995) this may be the reason for the differences observed.

The pH$_{24}$ of both the breast and leg and thigh quarter of the ducks ranged from 4.29-4.39, and 4.70-5.04; respectively. These values were lower than pH values obtained by Jacob & Hopkins (2014) on Muscovy ducks. It was found that the pH$_{24}$ for both breast and leg and thigh quarters were found to be 5.8 and 6.2; respectively. However, the ducks in this current study were raised in conditions that required little walking to access feed and water; thus contributing a high glycolytic potential which results in a low pH$_{24}$ (Warris, 2010).

Chicken breast usually drops to a pH$_{24}$ of 5.6-5.9; whereas leg quarter drops to a pH$_{24}$ of 6.1-6.4 (Rose, 1997). However, pH$_{24}$ of the breast and leg quarter
for ducks was observed to be lower than the pH in chickens. The low pH is caused by the anaerobic breakdown of glycogen and the production of lactic acid in the tissues (Van Laack & Kaufman, 1999). This low pH is important for the keeping quality of the meat by reducing bacterial growth (Rose, 1997).

The ultimate pH was observed to be lower in the breast than in the leg and thigh quarter of ducks. However, pH varies between muscles since muscles throughout the carcass vary in their level of glycogen, the rates of energy metabolism as well as their rates of temperature and pH decline, due to inherent metabolic differences and muscle size (Lavrie, 1991). As the animal dies due to loss of blood and the resulting anoxia the muscle cells continue to respire, producing and consuming Adenosine Triphosphate (ATP) leading to an accumulation of lactic acid and a change in the pH (Baeza et al., 1998).

SUMMARY

While early post-hatch feeding on the performance of other poultry species such as broilers has been extensively investigated, here we report an evaluation of this practice for Mule ducks. Overall at 0-7 days the cumulative feed intake and feed conversion differed among treatments. Further, the time of post-hatch feeding did not affect the weights of the bone, muscle and skin, and fat of the breast quarter. However, the weight of the bone for the leg and thigh quarter differed among the treatments (T1-T4). The pH was lower than the initial pH of both the breast and leg and thigh quarters overall feeding times.

CONCLUSION

Overall our results demonstrated that the body weights of the ducks increased over the 63 day period regardless of the time they were fed post-hatch. Additionally, the time the ducks were fed post-hatch did not influence the carcass performance of the ducks. Our research suggests that ducks be fed as early as possible post-hatch in order to enhance the growth performance.

ACKNOWLEDGMENTS

Authors thank Mr. Rashad Solomon, Mr. Adrian Paul, the workers at the University Field Station and the University of the West Indies, St. Augustine and the Department of Food Production for physical and financial support.

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