# Niacin and Tryptophan Requirements of Mule Ducklings Fed Corn and Soy-Based Diets[1]

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*ABSTRACT* Experiments were conducted to determine the dietary niacin and tryptophan requirements of mule ducklings fed a corn-soy basal diet. In niacin requirement experiments, day-old, straight-run mule ducklings were fed diets supplemented with graded levels of niacin for 3 weeks. The results showed that the minimum niacin requirement was 45 mg/kg of the diet. For the determination of the optimal tryptophan in the diet, day-old ducklings of mixed sexes were fed a starter diet for 1 week, and then fed for 12 days experimental diets with graded tryptophan levels and containing 18.0% crude protein and 3013 kcal ME/kg. The minimum tryptophan requirement for maximum growth and feed efficiency was .23% of the diet or 1.28% of the dietary crude protein.

Further experiments were performed by using a 3 (niacin 20, 50, and 80 mg/kg) × 4 (total tryptophan .13, .23, .33, and .43% of air-dried diet) factorial design to investigate the relationship between niacin and tryptophan. It was concluded that excess tryptophan could spare the ducklings' need for niacin. Conversely, excess niacin failed to compensate for a deficiency of tryptophan. Maximum growth was obtained and bowed-leg disorder was prevented by the addition of sufficient niacin or tryptophan to the basal diets.

*(Key words:* mule ducklings, niacin, tryptophan)

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## INTRODUCTION

Niacin is known to be required in the diet for several species of animals including ducks. It has been reported by Hegsted (1946) that the niacin requirement of young ducklings for rapid growth on a purified diet was approximately 25 mg/kg of ration. However, the niacin requirement for starting and growing ducks as recommended by the National Research Council (NRC, 1977) was 55 mg/kg. Later, Dean (1978) also recommended 55 mg niacin/kg diet for starting ducks.

The tryptophan requirement for chickens has been established (NRC, 1977), but information on tryptophan requirement of ducks is quite limited. Dean (1978) reported that the tryptophan level for White Pekin ducks at the starter stage was .24% of the diet.

Mule ducks in Taiwan are currently produced by crossing Muscovy drakes with F1 females of White Pekin drakes and white domestic ducks. Although mule ducks have been playing an important role in meat production for a long time, no information is available on the niacin and tryptophan requirements for mule ducklings. Consequently, the purpose of this study was to determine quantitatively the niacin and tryptophan requirements of mule ducklings and the interrelationships between these two nutrients.

## MATERIALS AND METHODS

Experiments 1 to 3 were designed to determine the optimal dietary niacin level, and Experiments 4 to 6 were set up to evaluate the optimal tryptophan in the diet for mule ducklings. Experiments 7 and 8 investigated the relationships between these two nutrients.

Day-old mule ducklings used in all experiments were purchased from a commercial hatchery and were raised in a battery brooder with wire floors (60 × 90 cm). In Experiments 1 to 3, the ducklings were randomly distributed into their respective groups of 10 birds for each treatment with equal numbers of males and females. During the first week, the ducklings were kept in the electrically heated brooder at a temperature of 32 ± 1 C. Feed and water were supplied *ad libitum* during the experimental period of 3 weeks. The pelleted diet was prepared through a 3/16-in die in a CPM pelleting machine. Individual body weights

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were taken at weekly intervals. Ducklings were fasted at least 4 hr before being weighed. In Experiments 4 to 8, day-old mule ducklings were fed a starter diet for 1 week. On the 8th day after hatching, feed was withdrawn for 6 hr, and the birds were then allowed access to the feed for 2 hr. After that the feed was again removed for 4 hr. The birds whose weight deviated from the mean with a standard deviation of ± 13 were discarded. Ten ducklings (5 males and 5 females) were then selected for each treatment group on the basis of their weight and vigor so that the average weight was similar in all groups. The experiments were conducted for a period of 12 days from 8 to 20 days of age. The ducklings were weighed individually at the beginning and end of each experiment. Feed consumption per group was also recorded.

The compositions of the basal diets are given in Table 1. Diets 1 and 2 were used for niacin and tryptophan requirement studies, respec-

TABLE 1. *Composition of the basal diets*

| | Diet | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| | (%) | | |
| Ingredients | | | |
| Yellow corn | 61.00 | 70.00 | 70.00 |
| Soybean meal, 44% | 30.00 | 13.00 | 13.00 |
| Gelatin | ... | 5.40 | 5.40 |
| Amino acid mixture[1] | ... | 2.00 | 1.95 |
| Soybean oil | 1.85 | 2.00 | 2.00 |
| Dicalcium phosphate | 1.90 | 2.20 | 2.20 |
| Limestone, pulverized | .65 | .50 | .50 |
| Iodized salt | .30 | .30 | .30 |
| Cellulose[2] | 3.00 | 3.00 | 3.00 |
| Mineral premix[3] | .50 | .50 | .50 |
| Vitamin premix, niacin free[4] | .50 | .50 | .50 |
| Choline chloride, 50% | .10 | .10 | .10 |
| DL-Methionine | .10 | ... | ... |
| L-Lysine | .10 | ... | ... |
| L-Glutamic acid | ... | .20 | .25 |
| Sodium bicarbonate | ... | .30 | .30 |
| Total | 100.00 | 100.00 | 100.00 |
| Calculated value | | | |
| Crude protein, % | 18.77 | 18.35 | 18.35 |
| Metabolizable energy, kcal/kg | 2942 | 3013 | 3013 |
| Niacin, mg/kg | 23.00 | 20.00 | 20.00 |
| Tryptophan, % | .24 | .15 | .15 |
| Analyzed value | | | |
| Crude protein, % | 18.05 | 17.95 | 18.00 |
| Moisture, % | 13.16 | 12.28 | 12.10 |
| Niacin, mg/kg | 28.00 | ... | 20.00 |
| Tryptophan, % | ... | .13 | .13 |

[1] Amino acid mixture supplied the following per kilogram of diet: L-lysine, 3.32 g; DL-methionine, 2.21 g; L-threonine, .89 g; L-histidine, .39 g; L-tyrosine, .88 g; L-isoleucine, .60 g; L-leucine, .19 g; L-valine, 1.10 g; L-glutamic acid, 10.42 g (Diet 3 supplied 9.92 g).

[2] Cellulose used in Diet 1 was α-cellulose from Sigma, whereas Diets 2 and 3 were Solka-Floc (BW-100) from Brown Company, Berlin, NH.

[3] Mineral premix contained the following per kilogram: $FeSO_4 \cdot 7H_2O$, 49.75 g; $MnSO_4 \cdot H_2O$, 30.77 g; $CuSO_4 \cdot 5H_2O$, 7.87 g; ZnO, 14.94 g; $Na_2SeO_3$, .04 g, and pulverized limestone to make 1,000 g.

[4] Vitamin premix supplied the following per kilogram of diet: vitamin A, 4,000 IU; vitamin $D_3$, 800 ICU; vitamin E, 10 IU; vitamin $K_3$, 2.0 mg; thiamin, 2.0 mg; riboflavin, 5.0 mg; pyridoxine, 2.0 mg; vitamin $B_{12}$, .03 mg; biotin, .10 mg; folic acid, .20 mg; calcium pantothenate, 10.0 mg; and glucose as carrier.

TABLE 2. *Niacin and tryptophan content of some feed ingredients*

| Ingredients | Experiments | Niacin | Tryptophan |
|---|---|---|---|
| | | (mg/kg) | (%) |
| Yellow corn | 1-3 | 28.60 | ... |
| | 4-6 | ... | .07 |
| | 7 and 8 | 22.40 | .06 |
| Soybean meal, 44% | 1-3 | 35.30 | ... |
| | 4-6 | ... | .58 |
| | 7 and 8 | 32.50 | .64 |
| Gelatin | 4-8 | 0 | .07 |

tively, and Diet 3 was used for the study of niacin-tryptophan interrelationship. Crystalline niacin (Merck) was used as the supplemental vitamin in the diet. Tryptophan was varied in the diets by adding the designated quantity of reagent grade L-tryptophan to basal Diets 2 and 3 in isomolar substitution for L-glutamic acid. The crude protein (N × 6.25), moisture, and niacin contents of the basal diets were determined according to the methods of Association of Official Analytical Chemists (1975). The tryptophan contents of the basal diets and feed ingredients were assayed by the method described by Matheson (1974). The analyzed values of niacin and tryptophan in the feed ingredients used are shown in Table 2.

Data on body weight gain were subjected to statistical analysis for differences among treatments according to Duncan's new multiple range test (Steel and Torrie, 1960). The minimum requirements for the respective nutrients for optimal growth were determined by regression analysis on body weight gain against respective nutrient levels in the diet.

## RESULTS AND DISCUSSION

The effects of niacin levels in the diet on body weight gain and feed efficiency are shown in Table 3. The ducklings receiving the basal diet alone had lower body weight gain with higher incidence of bowed legs as compared with those fed diets containing higher levels of niacin. The body weight gain of ducklings was significantly ($P<.05$) increased with the increase in the dietary niacin. When the dietary niacin content was supplemented with pure niacin to make the total up to 48 mg/kg, maximum growth rate was obtained and the

TABLE 3. *The effect of dietary niacin level on body weight gain and feed efficiency of mule ducklings from 0 to 3 weeks of age*

| Treatment[1] | | Average body weight gain (mean ± SD)[2] | | | Feed efficiency | | |
|---|---|---|---|---|---|---|---|
| | | Experiment | | | Experiment | | |
| Niacin added | Niacin level | 1 | 2[3] | 3 | 1 | 2 | 3 |
| (mg/kg) | | (g) | | | (feed/gain) | | |
| 0 | 28 | 350 ± 125[a] (7) | 175 ± 39[a] (8) | ... | 2.11 | 2.12 | ... |
| 5 | 33 | ... | 373 ± 84[b] (7) | ... | ... | 1.94 | ... |
| 10 | 38 | ... | 522 ± 66[c] (4) | 668 ± 39[a] (0) | ... | 1.87 | 2.00 |
| 20 | 48 | 718 ± 48[b] (0) | 586 ± 74[d] (0) | 695 ± 40[a] (0) | 1.87 | 1.85 | 1.95 |
| 30 | 58 | ... | 588 ± 68[d] (0) | 694 ± 83[a] (0) | ... | 1.92 | 1.97 |
| 40 | 68 | 671 ± 70[b] (0) | 618 ± 65[d] (0) | 686 ± 76[a] (0) | 1.98 | 1.96 | 2.01 |
| 50 | 78 | ... | ... | 709 ± 57[a] (0) | ... | ... | 1.98 |
| 60 | 88 | 700 ± 65[b] (0) | ... | 702 ± 71[a] (0) | 1.95 | ... | 2.03 |
| 80 | 108 | 719 ± 35[b] (0) | ... | ... | 1.95 | ... | ... |
| 100 | 128 | 704 ± 84[b] (0) | ... | ... | 2.00 | ... | ... |

[a,b,c,d]Means with different superscripts within the same column differ significantly ($P<.05$).

[1]Diet 1 was used as the basal.

[2]The number in parentheses represents the number of ducklings with bowed legs out of 10 ducklings in a treatment.

[3]Two linear regression equations for average weight gain in Experiment 2: $\hat{Y}_1 = -311.88 + 19.75X$; $\hat{Y}_2 = 505.18 + 1.59X$. Y represents body weight gain and X represents niacin content of the diets.

occurrence of bowed legs was completely prevented. Further increases in the dietary niacin level above 48 mg/kg showed no improvement in growth. These results were similar to those formerly observed in White Pekin ducklings (Scott and Heuser, 1952; Heuser and Scott, 1953). These authors reported that the addition of niacin at 22 mg/kg to the practical diet containing 30 mg niacin/kg gave a marked growth response and prevented bowed leg disorder in ducklings. Dietary niacin content had to be increased to a higher level than for chicks, which indicated either that the duckling had a relatively high niacin requiement or that much of the niacin in the basal diet was unavailable to the ducklings.

According to the data of Table 3, it can be seen that the feed efficiency was also affected by the niacin level in the diet. The feed-to-gain ratio decreased from 2.11 to 1.87 in Experiment 1 and 2.12 to 1.85 in Experiment 2 with the increase in dietary niacin from 28 to 48 mg/kg, respectively. It appeared that the maximum body weight gain and the best feed efficiency were obtained from these three experiments when the ducklings were fed a diet containing 48 mg niacin/kg from 0 to 3 weeks of age.

The data on body weight gain from Experiment 2 were subjected to regression analysis and plotted against the niacin level in the diet. Two regression lines were obtained. The results showed that the minimum requirement of niacin for ducklings was 45 mg/kg. This value was higher than the data described by Hegsted (1946) who used a purified basal diet. The niacin requirements for avian species may vary widely because 1) niacin is synthesized in the body from tryptophan and 2) much of the niacin present in some feedstuffs is in a bound form that is unavailable. According to Yen *et al.* (1977), the availability of niacin in corn and soybean meal for chicks was 30 and 100%, respectively. Thus, ducklings fed diets consisting primarily of corn might have a higher niacin requirement as compared with those fed purified diets. On the basis of available niacin, the calculated niacin requirement in this study would be 33 mg/kg.

The influence of the tryptophan level in the diet on the growth performance of mule ducklings is shown in Table 4. Increase in the dietary tryptophan from .13 to .18% or more resulted in a significant ($P<.05$) increase in body weight gain in Experiment 4. When the dietary tryptophan was brought up to .28%, maximum growth rate was obtained. An analysis of variance showed no significant difference in body weight gain among various treatments in Experiments 5 and 6. However, the growth rate of ducklings fed diets containing .23% tryptophan was consistently better than that fed the basal diet. From the average of three experiments, optimal feed efficiency was also obtained when the ducklings were fed diets containing .23% tryptophan (Table 4).

According to the linear regression of the

TABLE 4. *The effect of dietary tryptophan level on body weight gain and feed efficiency of mule ducklings from 8 to 20 days of age*

| Treatment[1] | | Average body weight gain (mean ± SD)[2] | | | | Feed efficiency[2] | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Experiment | | | | Experiment | | | |
| L-tryptophan added | Tryptophan | 4 | 5 | 6 | Avg | 4 | 5 | 6 | Avg |
| (%) | | (g) | | | | (feed/gain) | | | |
| 0 | .13 | 383 ± 38$^{a}$ | 432 ± 26$^{a}$ | 395 ± 50$^{a}$ | 403 | 2.27 | 2.23 | 2.23 | 2.24 |
| .05 | .18 | 435 ± 28$^{b}$ | 467 ± 54$^{a}$ | 414 ± 54$^{a}$ | 439 | 2.06 | 2.05 | 2.15 | 2.09 |
| .10 | .23 | 471 ± 39$^{bc}$ | 486 ± 55$^{a}$ | 408 ± 31$^{a}$ | 455 | 1.90 | 1.94 | 2.18 | 2.01 |
| .15 | .28 | 507 ± 45$^{c}$ | 442 ± 51$^{a}$ | 409 ± 55$^{a}$ | 456 | 1.84 | 2.07 | 2.15 | 2.02 |
| .20 | .33 | 466 ± 41$^{bc}$ | 448 ± 71$^{a}$ | 428 ± 31$^{a}$ | 447 | 1.89 | 2.11 | 2.07 | 2.02 |
| .25 | .38 | 465 ± 66$^{bc}$ | 428 ± 34$^{a}$ | 435 ± 43$^{a}$ | 443 | 2.03 | 2.20 | 2.05 | 2.09 |

$^{a,b,c,d}$Means with different superscripts within the same column differ significantly ($P<.05$).

[1] Diet 2 was used as the basal in which 50 mg niacin/kg was added to supply sufficient niacin.

[2] Regression equations for average weight gain from three experiments: $\hat{Y}_1 = 338.23 + 522X$; $\hat{Y}_2 = 479.24 - 93.65X$. Regression equations for feed efficiency; $\hat{Y}_1 = 2.52 - 2.30X$; $\hat{Y}_2 = 1.89 + .48X$.

TABLE 5. *The effect of tryptophan level on niacin requirement of mule ducklings from 8 to 20 days of age*

| Treatment[1] | | Average body weight gain (mean ± SD) | |
|---|---|---|---|
| | | Experiment | |
| Niacin | Tryptophan | 7 | 8 |
| (mg/kg) | (%) | (g) | |
| 20 | .13 | 206 ± 35[a] | 305 ± 56[a] |
| 50 | .13 | 412 ± 44[c] | 412 ± 45[b] |
| 80 | .13 | 419 ± 48[cd] | 415 ± 54[b] |
| 20 | .23 | 361 ± 46[b] | 436 ± 70[bc] |
| 50 | .23 | 437 ± 62[cd] | 436 ± 52[bc] |
| 80 | .23 | 411 ± 58[c] | 466 ± 49[bc] |
| 20 | .33 | 457 ± 61[cd] | 484 ± 45[c] |
| 50 | .33 | 469 ± 51[d] | 444 ± 67[bc] |
| 80 | .33 | 462 ± 21[cd] | 461 ± 47[bc] |
| 20 | .43 | 458 ± 46[cd] | 419 ± 73[b] |
| 50 | .43 | 437 ± 63[cd] | 421 ± 45[b] |
| 80 | .43 | 465 ± 69[cd] | 479 ± 42[c] |

[a,b,c,d]Means with different superscripts within the same column differ significantly ($P<.05$).

[1] Basal Diet 3 was used in the experiments.

body weight gain data from three experiments against the dietary tryptophan level in the diet, the minimum tryptophan requirements for the maximum growth and the optimal feed efficiency were .23% of the diet or 1.28% of the dietary crude protein. This result is different from the data described by Dean (1978), who recommended that the tryptophan requirement of White Pekin ducklings was 1.09% of the dietary crude protein.

Experiments 7 and 8 were factorial experiments involving three levels of niacin (20, 50, and 80 mg/kg) and four levels of tryptophan (.13, .23, .33, and .43%) to study the effect of the dietary level of tryptophan upon the niacin requirement. The results obtained are given in Table 5. Ducklings fed basal diets containing 20 mg niacin/kg of diet and .13% tryptophan had the lowest body weight gain and the highest incidence of bowed legs as compared to all other treatments. As the niacin level was kept low at 20 mg/kg, the body weight gain was increased with increasing tryptophan levels and maximum weight gain was obtained at .33% tryptophan. For the low tryptophan level (.13%) groups, a significant ($P<.05$) increase in growth was obtained by supplementing niacin to the diet. However, the amount of niacin added was not sufficient to produce maximum growth. From these data it appeared that the niacin deficiency in the basal diet could be corrected by supplementing the diets with either niacin or tryptophan. It also showed that excess tryptophan could spare niacin. Conversely, excess niacin failed to compensate for a deficiency of tryptophan. This was demonstrated by the addition of 80 mg niacin/kg to the diet containing .13% tryptophan, which did not improve weight gain as compared to those fed diets containing 50 mg niacin/kg and .13% tryptophan.

A summary of the main effect on the niacin-tryptophan relationship is given in Table 6. It could be concluded that as the tryptophan level in the diet was presented in excess of the requirement, the addition of niacin had no beneficial effect in weight gain of ducklings. However, when the ducklings were fed diets with a tryptophan content below or equal to the requirement, the supplementation of niacin in the diet significantly increased the growth performance of ducklings.

TABLE 6. *The main effect of various levels of niacin and tryptophan on body weight gain of mule ducklings from 8 to 20 days of age*[1]

| Niacin | Tryptophan | | | | Average |
|---|---|---|---|---|---|
| (mg/kg) | (%) | | | | |
| | .13 | .23 | .33 | .43 | |
| 20 | 256 | 399 | 471 | 439 | 391 |
| 50 | 412 | 436 | 457 | 429 | 434 |
| 80 | 417 | 439 | 462 | 472 | 448 |
| Average | 362 | 425 | 463 | 447 | |

[1] The data show means of body weight gain of Experiments 7 and 8.

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