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NICOTINIC ACID REQUIREMENTS FOR BROWN LAYING HENS AT END PRODUCTION CYCLE UNDER EGYPTIAN CONDITIONS

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SUMMARY

Twenty hundred and eighty Hi-Sex brown laying hens were individually allocated in two deck batteries at open house system form 48 wks to 60 wks of age to predict the exact dietary nicotinic acid (NA) requirement for hen's performance, egg quality and economical efficiency under Egyptian conditions. Birds were randomly divided into 5 groups with 4 replicates of 14 hens each, where hen's basal diet were supplemented with ascending gradual levels of NA (0.0, 20.0, 40.0, 60.0 or 80.0 mg/kg diet). The diet of 40 mg/kg supplementation is representing the strain guide recommendation. NA comes from main ingredients were canceled. Results revealed that as a trend, laying hens performance was improved with increasing the NA level in the laying hen diets. The hens received 80.0 mg NA/kg diet exhibited the best egg produced, egg mass and feed conversion ratio compared with other groups. Niacin had no significant effect (P> 0.05) on either external or internal egg quality measures except both albumen and yolk index. In conclusion; the increasing of NA level over the recommended may lead the hens to enhance their performance, improve FCR and economical efficiency. Therefore, the laying hen requirement of NA at the end of production cycle may be increased over than 40.0 mg/kg; perhaps between 60-80 mg/kg.

Keywords: *Nicotinic Acid– vitamins requirements - Laying hens- performance*

INTRODUCTION

Nicotinic acid; Niacin; Nicotinamide (NA) is a vitamin of B-complex group touching as the precursor of NAD+/NADH and NADP+/NADPH, participates in many biochemical processes, e.g. metabolism of lipid (Yang *et al*., 2016) oxidation of tissue, glycolysis, and functions of respiratory (Smith *et al*., 2009; Du *et al*., 2010). Therefore, NA has vital roles in mitochondrial respiration, carbohydrates, lipids and amino acids metabolism (Lonza, 2012). Many authors reported that NA is a functional source of niacin (Harms *et al*., 1988; Oduho and Baker, 1993; Real *et al*., 2002 and Ivers and Veum, 2012). The laying hen requirements of NA ranged from 10–35 mg/kg in their diets according to NRC (1994) and 25–100 mg/kg according to AWT (2002). Margin safety of NA is no less than ten times the requirements (Lonza, 2012). Gungor *et al*., (2003) illustrated that many factors influenced the absorption and utilization of NA such as interaction with macronutrients in cereals, diet tryptophan, pyridoxine (vitamin B_6) levels and levels of supplementation. In addition to, if the requirements of tryptophan exceeds it can be produce NA in the body (McDowell, 1989 and NRC, 1994); however, the efficacy of mechanism is low (Lonza, 2012); where, it takes about 50 to 60 mg of tryptophan to produce 1 mg of NA (Kating and Drephal, 1974). Supplementation of NA in Laying hen diets can influence the performance and might be reached to 1500 mg/kg (Gungor *et al*., 2003; Kurtoglu *et al*., 2004 and El-Husseiny *et al*., 2008).

According to the most recent official public vitamin requirements are from the NRC (1994); it is quite difficult to determine the vitamin needs in practical laying hens nutrition. The goal is to prevent vitamin deficiency disorders and to support optimum health and ensure good egg production. It may be well known that common feed ingredients are not recommended as sources for supplying vitamins. There is also extensive variation in vitamin recommendations according to environmental effects, growing conditions, management, disease, diet considerations and strain (Ward, 1993). Higher levels can be recommended when the flock facing challenges such as high stocking density and severe internal or external microbial challenges and the loss in vitamins efficacy that occur during feed processing and consumption by the bird. Commercially, NA requirements of laying hens in normal conditions ranged between 40-60 mg/kg. Thus, this work was to detect the exact NA requirements for brown laying hens from 48-60 wks. old under Egyptian conditions.

MATERIALS AND METHODS

The effect of dietary Nicotinic Acid (Niacin), NA, levels in commercial laying hen diets on performance, egg quality and economical efficiency was evaluated and executed in Poultry Research Unit, Faculty of Agriculture, Cairo University, Giza, Egypt from September to December 2015. The experiment was conducted under the guidelines of the institutional Ethics of Animal Use in Research Committee (EAURC), Cairo University, Egypt.

Husbandry and Experimental Design

Two Hundred and eighty Hi-Sex Brown laying hens at 48 wks old were randomly and separately divided into 5 treatments, each treatment had 4 replicates of 14 hens each, where hens fed basal diets supplemented with NA at levels 0.00, 20.0, 40.0, 60.0 or 80.0 mg/kg diet. Hens were housed in 2 deck battery at an open house system under the same managerial conditions with ceiling fans. Birds fed layer basal diet contained 17.4% crude protein and 2750 K.cal ME/kg during the experimental period up to 60 wks of age (Table 1). Diets were formulated to meet the nutritional recommendations of Hi-Sex Brown laying hens. The light program consisted of 16.5 h of light/d throughout the experiment (48 to 60 wks. of age). Feed and water were presented *ad-libtum*.

Table (1): Composition and calculated analysis of experimental basal diet

Ingredients	%
Corn, Grain	58.31
Soybean Meal-44	28.3
Soybean Oil	1.88
Limestone	9.93
Mono-calcium - Phos	0.84
Common Salt	0.300
Premix	0.300
DL-Methionine	0.14
Total	100.0
Chemical analysis (Calculated)	
ME K.cal/kg	2750
CP%	17.4
Ca%	4.0
Av Ph%	0.32
Meth%	0.42
Lys%	0.91
Meth+ Cys%	0.73

[2]*Each 1 kg diet contains vitamin A 10000 IU, vitamin* D_3 *2500 IU, vitamin E 20 mg, vitamin* K_3 *3.0 mg, vitamin* B_1 *1.0 mg, vitamin* B_2 *5.0 mg, vitamin* B_6 *3.0 mg, Vitamin* B_{12} *0.015 mg, pantothenic acid 10.0 mg, nicotinic acid 30 mg, folic acid 1.0 mg, Biotin 0.05 mg, manganese 100 mg, zinc 60 mg, iron 33 mg, copper 9 mg, iodine 1.0 mg, selenium 0.3 mg and cobalt 0.20 mg.*

Productive Performance

Body weight (BW) was recorded at the beginning and at the end of the experiment. All the eggs produced were individually weighed and egg number was recorded per each replicate. Feed consumption was recorded every 4 wks. These previous records were used cumulatively to calculate BW Change (BWC), egg production rate (ER), egg mass (EM), average daily feed intake (FI), and feed conversion ratio (FCR, g feed: g egg).

Egg quality

Two eggs from each replicate were similarly selected, 8 eggs per treatment every period, to measure the following measurements: Shape index%= egg width/egg height x 100, Shell thickness was determined using a dial pipe gauge. Dry shell with membranes (ESW) was weighed to the nearest 0.1 g and shell% were calculated (ESW/EW*100). The heights of albumen and egg weight were used to calculate Haugh units (HU) according to Eisen *et al*., (1962). Albumen index (AI) = height/diameter mean × 100. Yolk index = (yolk height (mm)/yolk diameter (mm) x 100 according to Funk, (1948).

Economical efficiency

Economical efficiency of egg production and relative economical efficiency, were calculated from the input-output analysis. This was calculated according to the price of the experimental diets and eggs produced. The values of economical efficiency (EE) were calculated as the net revenue per unit of total cost. Prices of the supplemented NA were taken into consideration. The relative economical efficiency was calculated as EE of treatments/EE control*100.

Statistical Analysis

The experimental design was completely randomized with 5 treatments (each with 4 replicates). The experimental unit (replicate) consisted of a group of 14 hens. Data were statistically analyzed by analysis of variance (ANOVA) one-way using General Linear Model (GLM) Procedure of SAS software (SAS Institute, 2004). The differences among treatments means were subjected to significance P< 0.05 and P< 0.10 which were considered as a trend. Orthogonal polynomial contrasts were performed to study the linear and quadratic effects of dietary NA levels on all traits. Results in tables are presented as least square means ± SEM by Duncan's Multiple Range-test (Duncan, 1955), where the statistical model was:

$Y_{ij} = \mu + T_i + e_{ij}$ Where:

Y_{ij} = Observed value of a given dependent variable.

μ = Overall adjusted mean.

T_i = Fixed effect of treatments, where i=1, 2… etc.

e_{ij} = Random error associated to each observation.

Using SPSS software program to predict the optimum level of NA level via estimation curve analysis (IBM Corp-Released, 2017).

RESULTS AND DICUSSION

Productive performance

The effects of NA levels on egg production rate (EP, %), egg weight (EW, g), egg mass (EM, g), feed intake (FI, g), FCR, and body weight change (BWC, g) are presented in Table (2). Although the 80 mg NA/kg diet level increased EP but it was not significant (P< 0.05). Also, NA levels effect were not significant on EW, EM and FI but were significant on FCR and BWC. The hens received 80.0 mg NA/kg diet showed the best EP, EM and FCR compared with other groups. As a trend, the performance results showed an improvement with increasing the NA level in the laying hen diets. No linear or quadratic effects were noted for all productive traits except for FI, FCR and BWC (Table 2). According to figures from 1 to 3, The optimum NA level might be between 60 and 80 mg/kg. The data herein showed that increasing the NA level over than the recommended level may lead the hens to enhance their performance and improve FCR via slight decreasing FI and increasing the egg number produced. Therefore, the laying hen requirement of NA at finish of production cycle may be increased over than 40.0 mg/kg.

The vital role of niacin was in utilization of calcium and phosphorus that laying hen require to produce optimum level of egg production according to Leeson *et al*., (1979). Our results documented that supplemental niacin to corn soybean-based diets of layers did not significantly affect on egg production as confirmed by several articles (Jensen et al.,1976; Ouart *et al*., 1987; Harms, 1988; Gungor, *et al*., 2003; Kurtoglu *et al*., 2004 and El-Husseiny *et al*., 2008). On the other hand, Leeson *et al*. (1991) indicated that egg production was significantly improved by NA supplementation (44, 66 and 132 mg/kg) to laying hen diet vs. 22 mg/kg. Kucukersan (2000) found that egg production increased linearly with 50 and 100 ppm supplemented niacin. Several studies confirmed our results that no effect of additional niacin in laying hen diets on was observed egg weight and egg mass values (El-Husseiny *et al*., 2008; Gungor *et al*., 2003 and Leeson *et al*., 1991). El-Husseiny *et al*. (2008) concluded that 30 mg NA/kg significantly decreased FI and improved FCR against 150, 300 and 450 mg/kg. Although, Gungor *et al*. (2003) and Kurtoglu *et al*. (2004) observed no effect on FI due to NA levels and FCR improved with NA supplementation. According to BWC results, Gungor *et al*. (2003) observed that BW gain increased with increasing NA level. However, El-Husseiny *et al*. (2008) noticed that BWG were significantly decreased with increasing NA level.

Table (2): Effect of dietary niacin levels on productive performance of laying hens from 48 to 60 wks. of age.

Parameter	Niacin mg/kg diet					SEM[1]	Effects		
	0.0	20.0	40.0	60.0	80.0		*P value*	*Linear*	*Quad-ratic*
Egg production (%)	93.0	93.3	93.6	93.8	95.4	0.72	0.30	0.07	0.25
Egg weight (g)	61.3	61.9	60.8	62.6	61.6	0.59	0.35	0.74	0.57
Egg mass (g)	57.0	57.8	56.9	58.8	58.8	0.64	0.14	0.09	0.17
Feed intake (g/bird/d)	108.5	108.3	108.8	108.7	107.6	0.34	0.12	0.30	0.05
Feed conversion ratio (g:g)	1.88[ab]	1.91[a]	1.91[a]	1.85[bc]	1.83[c]	0.02	0.03	0.04	0.04
Body weight change (g)	80.9[a]	30.7[c]	60.9[ab]	55.1[bc]	52.1[bc]	6.62	0.01	0.50	0.01

** a, b and c means in each row bearing the same superscripts are not significantly different (P<0.05). * 40 mg niacin/kg considered as control*

Egg quality

The effects of NA levels on egg shape index (%), egg shell (%), egg shell thickness (mm), Haugh units (%), egg contents percentage (%), yolk index (%) and albumen index (%) are presented in Table (3). NA had not significantly affect (P< 0.05) on either external (shape index, egg shell, egg shell thickness) or internal (egg content % and Haugh units) egg quality measures except both albumen and yolk index. Generally, no adverse effects were detected when NA supplemented to laying hen diets at either lower or higher than the strain guide recommendation (40.0 mg/kg diets) where the values were within normal range. No linear or quadratic effects were noted for all egg quality traits except for linear effect on yolk index. No significant differences between hens received 80.0 mg NA/kg and those received 40.0 mg/kg were detected.

The results of egg quality showed that NA level lower than and greater than recommended level (40.0 mg/kg) may have an effect on internal egg quality parameters, especially, albumen and yolk index. These results may attribute to the effect of NA on many biochemical processes, e.g. lipid metabolism, tissue oxidation, glycolysis, and respiratory functions (Yang *et al*., 2016; Smith *et al*., 2009; Du *et al*., 2010). These results are confirmed by those obtained by Gungor *et. al*., (2003) who observed that no effect was detected on egg shape index due to NA supplementation, while Albumen index, were significantly affected by the addition of NA. On the other hand, El-Husseiny *et al*. (2008) noticed that NA levels 150, 300 and 450 mg/kg improved egg shell thickness and egg shell percentage than 30 mg /kg. Moreover, Gungor *et al*., (2003) noticed significant increase in egg shell thickness with increasing NA level (250, 500, 1000 and 1500 mg/kg diet). Lesson *et al*. (1991) concluded that no significant effect by NA levels on yolk weight was observed.

Table (3): Effect of dietary niacin levels on egg quality parameters of laying hens from 48 to 60 wks of age.

Parameter	Niacin mg/kg diet*					SEM[1]	Effects		
	0.0	20.0	40.0	60.0	80.0		*P* value	Linear	Quadr-atic
Shape index (%)	80.4	77.3	79.7	79.4	78.0	0.54	0.16	0.92	0.37
Egg shell (%)	9.7	9.8	9.9	10.2	9.9	0.16	0.96	0.55	0.67
Egg shell thickness (mm)	0.420	0.440	0.430	0.450	0.430	0.01	0.51	0.15	0.44
Haugh units (%)	91.9	84.1	90.4	86.0	93.6	1.57	0.06	0.95	0.19
Egg content (%)	90.3	90.2	90.1	89.8	90.1	0.16	0.96	0.55	0.67
Yolk index (%)	46.0[a]	45.2[ab]	44.4[bc]	42.5[c]	44.7[bc]	0.56	0.02	0.02	0.60
Albumen index (%)	13.2[ab]	10.8[c]	13.6[a]	12.2[bc]	13.2[ab]	0.38	0.04	0.50	0.11

*a, b and c means in each row bearing the same superscripts are not significantly different (P<0.05). * 40 mg niacin/kg considered as control*

Economic efficiency

The net revenue divided by total feed cost calculations are offered in Table (4). Egg prices income increased gradually with increasing NA level due to the egg number increasing with NA level increasing. Accordingly, the net revenue increased gradually with increasing NA level. Therefore, the values of economical efficiency were almost the same in all groups except that received 80.0 mg NA/kg diet which had the best either economical efficiency and relative economical efficiency values. Lesson, (1991) mentioned that economic benefits will be the best when higher levels of dietary niacin were presented than presently recommended by NRC. However, El-Husseiny *et al*. (2008) noticed that REE values were decreased with increasing NA level.

Table (4): Effect of dietary niacin levels on economical efficiency of laying hens from 48 to 60 wks of age.

Item*	Niacin mg/kg diet 0.0	20.0	40.0	60.0	80.0
Egg production rate (%)	93.0	93.3	93.6	93.8	95.4
Egg number (#)	78.1	78.4	78.6	78.8	80.1
Egg price income (LE)	91.1	91.4	91.7	91.9	93.5
Feed consumption g/hen/day	108.5	108.3	108.8	108.7	107.6
Total feed consumed (kg)	9.11	9.10	9.14	9.13	9.04
Feed price LE/kg	4.843	4.846	4.850	4.853	4.857
Total feed cost (LE)	44.1	44.1	44.3	44.3	43.9
Net revenue (LE)	47.0	47.3	47.4	47.6	49.6
Economic efficiency (EE)	1.066	1.074	1.070	1.074	1.130
Relative economic efficiency REE (%)	0.966	100.37	100.00	100.37	105.61

**Net revenue = Egg price income (LE) – Total feed cost (LE), EE= Net revenue/Total feed cost and REE= EE treatment/ EE of control*100. * 40 mg niacin/kg considered as control*

CONCLUSION

Generally, the hens received 80 mg NA/kg diet performed better than the other groups received 0, 20, 40 and 60 mg NA/kg and, therefore it had the best economical efficiency. The groups received the different NA levels except 80.0 mg/kg diet were almost showed similar performance and economical efficiency. So, it could be concluded that NA requirements may be over than 40.0 mg/kg at the end of laying hen production cycle from 48 to 60 wks old under Egyptian conditions.

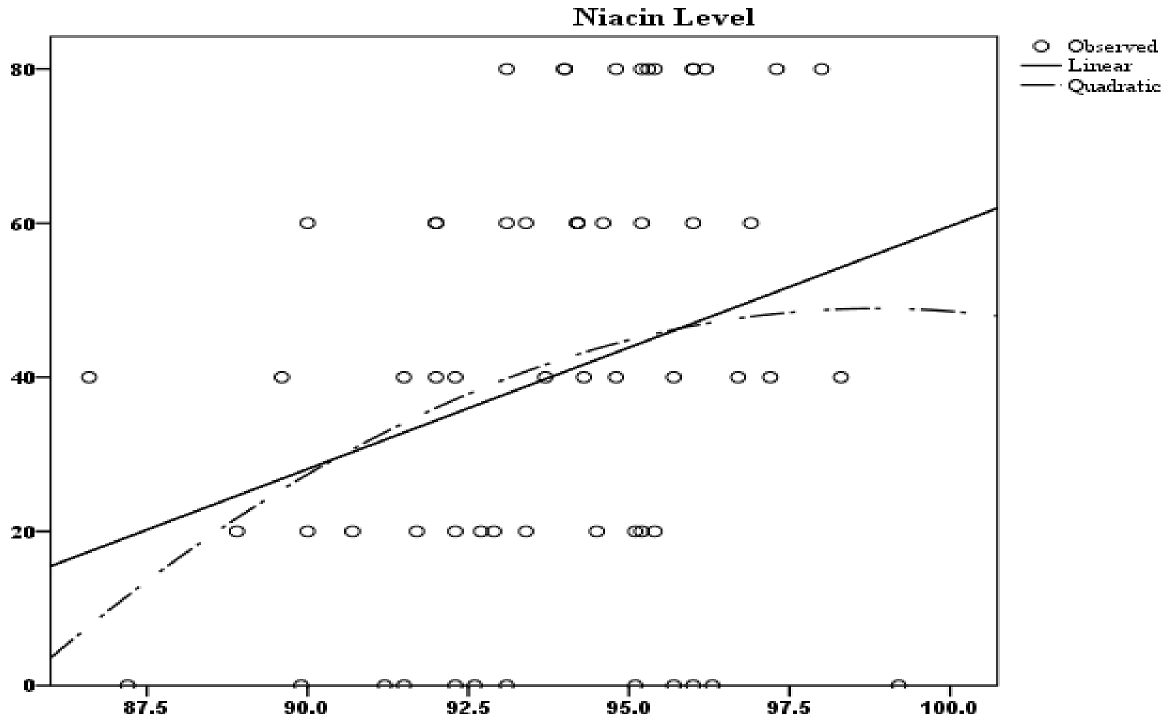

Figure (1): Niacin level prediction via egg production with linear and quadratic effect.

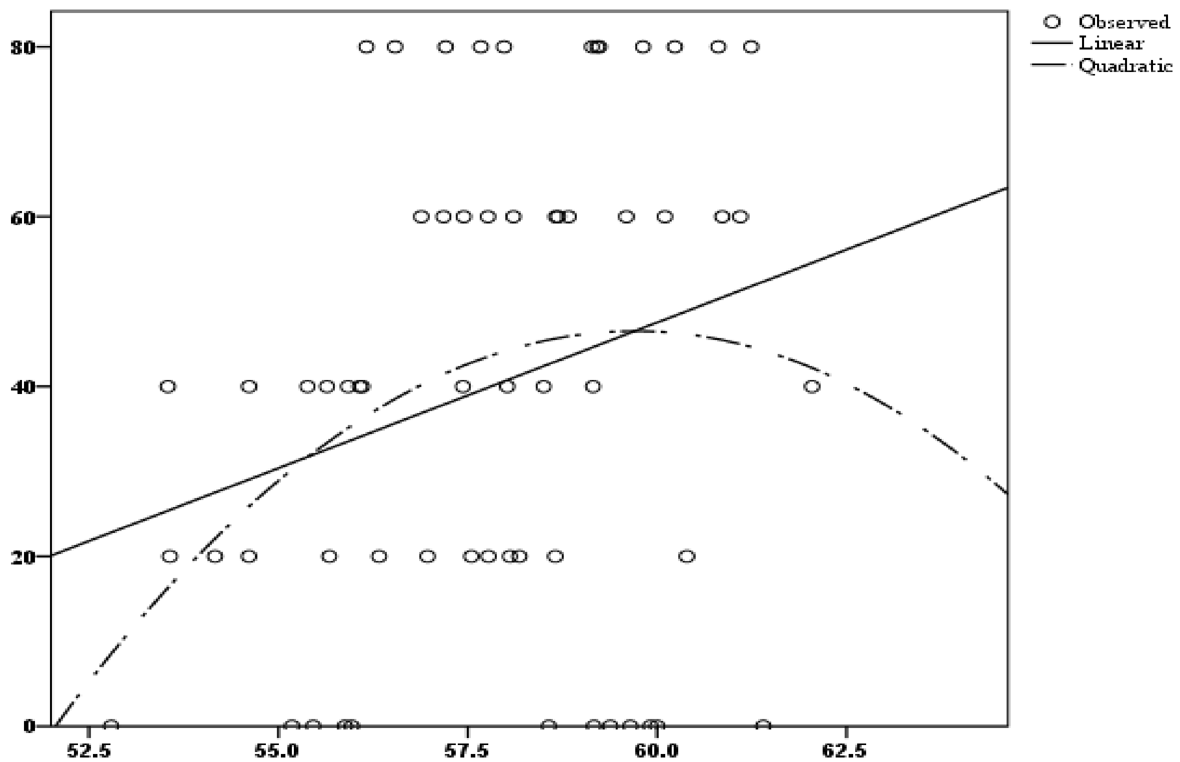

Figure (2): Niacin level prediction via egg mass with linear and quadratic effect.

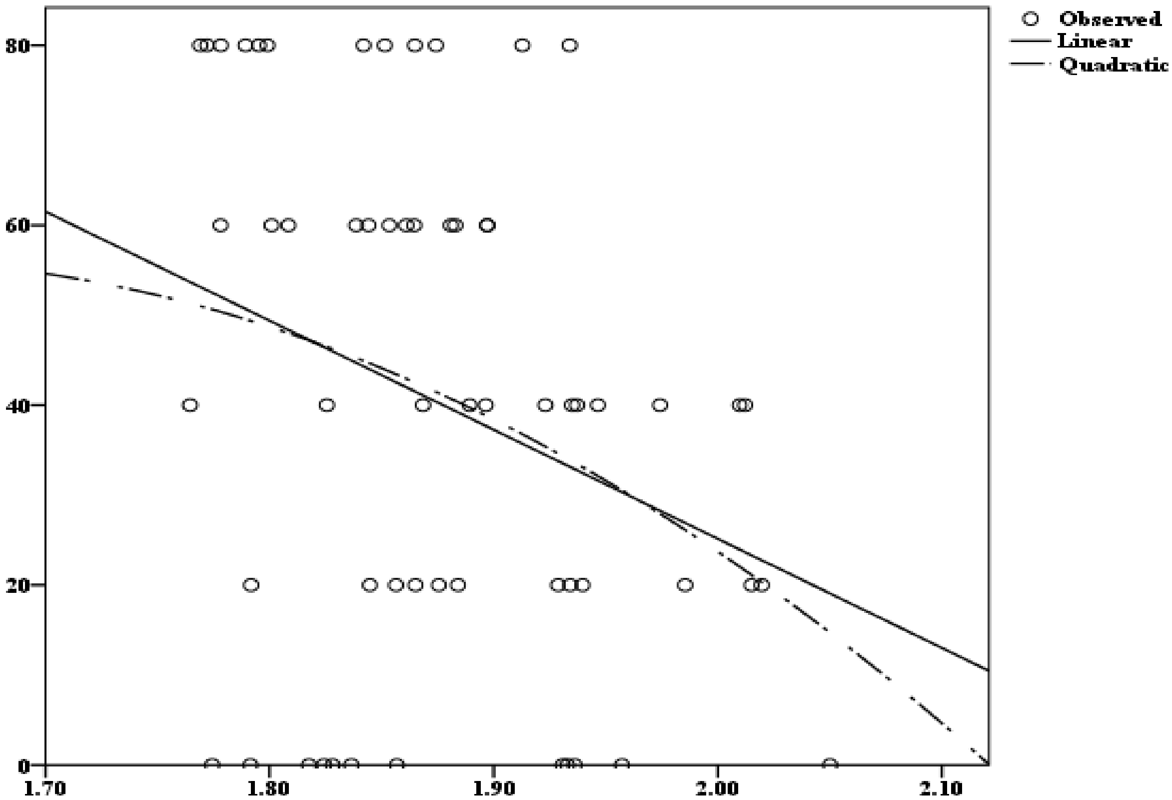

Figure (3): Niacin level prediction via feed conversion ratio with linear and quadratic effect.

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الاحتياجات من حامض النيكوتينيك خلال فترة نهاية الإنتاج للدجاج البياض البنى تحت الظروف المصرية

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تم تسكين عدد ٢٨٠ دجاجة بياض نوع هاى سكس بنى فرديًا فى بطاريات هرمية ذات صفين فى عنبر مفتوح من عمر ٤٨ إلى ٦٠ أسبوع وذلك للتنبؤ بأفضل مستوى للنياسين مناسب لانتاج البيض، وجودة البيضة والكفاءة الاقتصادية تحت الظروف المحلية المصرية. تم تقسيم الطيور عشوائيًا إلى ٥ مجاميع، ٤ مكررات، ١٤ دجاجة لكل مكرر . تم تغذية الطيور على عليقة أساسية اضيف اليها مستويات تصاعدية من النياسين (صفر، ٢٠، ٤٠، ٦٠ و ٨٠ مجم/كجم عليقة). تمثل العليقة التى احتوت على ٤٠ مجم/كجم احتياجات السلالة مع تجاهل النياسين الموجود فى خامات العلف.

أوضحت النتائج كتوجه عام، تحسن فى أداء الدجاج البياض فى الفترة من ٤٨-٦٠ أسبوع مع زيادة مستوى النياسين فى العليقة. أظهرت الطيور التى تغذت على مستوى ٨٠ مجم/كجم أفضل انتاج بيض، كتلة بيض، كفاءة تحويل غذائى بالمقارنة مع باقى المجاميع. لم تؤثر مستويات النياسين على قياسات جودة البيضة الداخلية والخارجية عدا دليل الصفار و دليل البياض.

يمكن إستنتاج أن مستوى نياسين أعلى من ٤٠ مجم/كجم من الممكن أن يحسن من أداء الدجاج البياض وكفاءة التحويل الغذائى والكفاءة الاقتصادية عند هذا العمر و من المحتمل أن يكون بين ٦٠-٨٠ مجم/كجم.