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Influence of different levels of calcium and vitamin D_3 in cassava-based diet on the performance of laying hens

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Abstract

This study was conducted to determine the influence of different levels of calcium and vitamin D_3 in a cassava-based diet on performance of laying hens. One hundred and eight Isa Brown hens which were 34 weeks' old were used in a three by two factorial arrangement in a complete randomized design. Birds were fed diets containing different levels of calcium (A= 2.5%, B= 3.5%, and C= 4.5%), with each calcium level also containing vitamin D_3 at levels of 2000, 4000 and 6000 IU. All birds were raised under the same management condition within the nine treatment combinations which had three replicates of four (4) birds each. Records of the feed intake, egg lay, cost of feed ingredients and mortality were documented. The records were used to calculate the hen-day production (HDP), feed intake, number of eggs laid per hen, dozens of eggs laid per hen, feed consumed per dozen egg, feed cost per dozen egg produced and mortality. The result obtained showed that diets B (3.5%), C (4.5%), the 2000 IU vitamin D_3 level and diet C (4.5% calcium) containing 2000 IU vitamin D_3 were better in terms of the number of eggs laid per egg, hen day production, and dozen egg per hen. Thus, farmers can use 3.5%, 4.5% calcium levels or 2000 IU vitamin D_3 levels singly/individually in diet for laying hens and obtain better result. However, the C diet (4.5% calcium) containing 2000 IU vitamin D_3 which had the highest number of eggs, HDP, dozen egg per hen, best feed conversion to eggs as well as the least cost of production is recommended for laying hens in the humid tropics, when calcium and vitamin D_3 are used together in a cassava-based diet to feed hens.

Keywords: Calcium, Hens, Interaction, Performance, Vitamin D_3, Interaction

Introduction

Calcium is one of the essential minerals in poultry production. Not only do calcium play a vital function as the main component of bone structure and participation in acid-base balance and enzymatic system but laying hens needs high calcium especially during egg formation, as deficiency of calcium results in decrease in egg production and mobilization of calcium from the bone (Leeson and Summers, 2005). The nutritional role of calcium is closely linked to that of phosphorous and to the effect of vitamin D (Pelicia *et al.,* 2009). However, incorporation of limestone and oyster shell as calcium sources into the feed of hens had been reported to have no effect on egg production and the price tag of limestone is relatively high compared to oyster shell. (Leeson and Summers, 2005). The appropriate level of calcium to be used in diets of laying birds is 3.25% at a feed consumption of 100g/bird/day (NRC, 1994). However, Pastore *et al.* (2012) reported that a calcium consumption of 3.51g/bird/day and available phosphorous of 289mg/bird/day would meet the requirements of calcium and available phosphorous of white egg layers up to 42 to 58 weeks of age. Calcium supplementation is necessary in animal feed since most of the animal feed consist of grain and its by-

products which are usually low in calcium level (Peixoto and Rutz, 1988, Pelicia *et al*., 2009). When diets cannot meet the nutritional requirements of layers, it impairs the performance and egg quality (Keshavarz and Nakajima (1993). Whitehead (2004) stated that the liable source of calcium is the medullary bone which helps in egg shell formation. Majority of eggs sold in Nigeria are still intact with the shell on it and a consumer's first impression of a purchased egg is based on their perception of the shell quality (Okoli and Udedibie, 2000). A major problem in commercial laying hens once they enter the laying phase is bone fractures (Fleming *et al*., 2004; Sandilands *et al.,* 2009). Cholecalciferol (Vitamin D_3) plays an important role in laying hens in terms of calcium metabolism (Rennie *et al.,* 1997; Whitehead and Fleming, 2000, Fleming *et al.,* 2006). Inadequate calcium in diet and its metabolism has been linked to bone fractures in laying hens.

Cassava is a high energy crop which is widely grown and usually available throughout the year in Nigeria. It thrives well in the tropics. Its adaptability is vast and it has a strong resistance to drought and tolerance to poor soils (Tewe, 1994). According to Okoli (2008), Nigeria was ranked as the world's largest producer of cassava with a production capacity of 40 million tonnes. But, Calpe (1991) stated that the use of cassava in animal feed accounted for only 2% in Africa. According to Aduku (1993), the metabolizable energy of cassava for poultry is 3279 Kcal/kg compared to that of maize for poultry which is 3432 Kcal/kg while Olugbemi *et al.* (2010) stated same value of 3279 Kcal/kg as the metabolizable energy of cassava for poultry. But the report of Buitrago *et al*. (2002) gave a range of 3000 - 3200 Kcal/kg while Egena (2006) obtained 3200 Kcal/kg of ME for poultry in cassava root meal. Smith (2003) however, reported that the chemical composition of cassava varies according to their variety, age and processing technique while its protein content (2.5%) is lower than that of yellow maize (8.5%) while Stupak *et al*. (2006) stated that the protein content of cassava root meal is 1 to 3 %. Although, Oruwari *et al.* (2003) stated that with proper protein balance, cassava meal could completely replace maize in poultry diets. Reduction in cost of production can be achieved with the use of cassava as an alternative to conventional energy feedstuff like maize (Ukachukwu, 2005). According to Oruwari *et al* (2003), one of the advocated alternatives for partial replacement of maize in the poultry diet is processed cassava root meal. Akinola and Oruwari (2007) reported an increase in egg production as the level of cassava root meal was increased in layers' diets.

Vitamin D_3 is a fat-soluble vitamin required for calcium and phosphorus utilization of the body (Combs, 1998). Many studies have been conducted on deficiencies of D_3 (rickets, osteoporosis and osteomalacia) and have shown how important this vitamin is for bone development and retention in the youth and elderly (Combs, 1998). Vitamin D supplementation is closely related to decrease incidence of bone disorders because vitamin D is involved in various physiological processes, including the absorption of calcium and phosphorus and bone mineralization and mobilization (Rennie and Whitehead, 1996; Driver *et al*., 2005; Korver, 2005; Kasim *et al.,* 2006). Also, commercial layers are usually reared indoors, and do not receive solar radiation (which helps in production of Vitamin D_3) to convert 7-dihydrocholesterol to produce Vitamin D_3. This is why Vitamin D_3 is sometimes added to layer feeds for the maintenance of egg production, egg and shell formation and calcium homeostasis.

Several researchers have reported the importance of using cassava, calcium and

vitamin D_3 separately in poultry diets. Thus, this study examined the influence of the combination of different levels of calcium and vitamin D_3 in cassava-based diet on the performance of laying hens.

Materials and methods

Experimental location

The experiment was carried out at the Poultry Unit of the University of Port Harcourt Teaching and Demonstration Farm, Port Harcourt. The Farm is located between longitude $6^0$55N to $7^0$10E and latitude $4^0$35N and $4^0$54N of the Greenwich meridian. The daily temperature during the study period (June to September) was 22 – 29 ^{0}C while the average low temperature was 21 – 22 ^{0}C. The average annual rainfall of the area is 2708mm.

Experimental animal, management and design

One hundred and eight Isa brown laying hens were used for this research. The birds were randomly assigned into nine groups in a 3 × 2 factorial arrangement of the completely randomized design (CRD). The two factors were calcium and vitamin D_3. Each factor had three levels namely: calcium, 2.5%, 3.5% and 4.5% and vitamin D_3, 2000 IU, 4000 IU and 6000 IU. Thus, there were nine treatment combinations with three replicates each having four hens per replicate. Routine management practices and hygienic conditions were maintained throughout the period of the study to ensure maximum result.

Experimental feed and duration

The diets were compounded from the ingredients bought, such that the calcium levels in the treatments were 2.5%, 3.5%, 4.5%, while the levels of vitamin D_3 were 2000 IU, 4000 IU and 6000 IU as shown in Table 1. The calcium sources were obtained from bonemeal and limestone while the major energy source for the 2.5% and 4.5 % calcium levels was cassava root meal. The experiment lasted for 12 weeks.

Data collection

Daily egg production record was kept during the experiment and was used to obtain the number of eggs laid, hen-day production (HDP), and dozens of eggs laid while the feed intake record along with the egg record were used to calculate the feed conversion ratio (feed/dozen egg). The cost of ingredients and the feed intake were used to calculate the feed cost per dozen egg produced. The mortality record was also collated.

Data analysis

The data generated were analyzed using the General Linear Model Procedure of the SPSS while significant differences in the mean were separated using Duncan Multiple Range Test (DMRT).

Results

Effect of different calcium levels in diets on the performance of hens

The effect of different calcium levels in diets on the performance of hens is shown in Table 1. The diets significantly ($P < 0.05$) affected the number of eggs laid per hen, hen-day production (HDP), dozen egg/hen, feed intake, feed/dozen egg (feed conversion) and feed cost/dozen egg while mortality was not affected. The highest number of eggs laid per hen, HDP and dozen egg/hen were obtained from the birds fed the B and C diet while those fed the A diet had the lowest number of eggs, HDP and dozen egg/hen. The birds fed diet A had the highest feed intake and feed conversion (feed/dozen egg) followed by those fed the B diet, while the hens fed the C diet had significantly ($P < 0.05$) lower feed intake and feed conversion (feed/dozen egg). The feed cost per dozen egg was however significantly ($P < 0.05$) higher for diet A (₦286.17) followed by diet C and lastly, diet B (₦234.71). There was no mortality during the period of study.

Table 1: Composition of experimental layers diets

Ingredient (%)	A			B			C (4.5% Ca)		
	(2000 IU Vit. D_3)	(2.5%Ca) (4000 IU Vit. D_3)	(6000 IU Vit. D_3)	(2000 IU Vit. D_3)	(3.5%Ca) (4000 IU Vit. D_3)	(6000 IU Vit. D_3)	(2000 IU Vit D_3)	(4000 IU Vit D_3)	(6000 IU Vit D_3)
Maize	0.00	0.00	0.00	23.5	23.5	23.5	0.00	0.00	0.00
Palm kernel cake	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5
Cassava Root meal	23.5	23.5	23.5	0.00	0.00	0.00	23.5	23.5	23.5
Soya bean meal	10.7	10.7	10.7	8.2	8.2	8.2	10.7	10.7	10.7
Groundnut cake	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3
Fish meal	1.6	1.6	1.6	1.3	1.3	1.3	2.5	2.5	2.5
Wheat bran	6.0	6.0	6.0	7.0	7.0	7.0	1.8	1.8	1.8
Palm oil	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Limestone	2.2	2.2	2.2	3.2	3.2	3.2	3.9	3.9	3.9
Bone meal	1.6	1.6	1.6	2.5	2.5	2.5	3.2	3.2	3.2
DL-Methionine	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Lysine	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Vit/TM Premix	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100	100	100	100	100
Nutrient Composition									
Crude Protein	18.75	18.75	18.75	19.33	19.33	19.33	18.66	18.66	18.66
ME kcal/kg	2538.44	2538.44	2538.44	2503.06	2503.06	2503.06	2494.52	2494.52	2494.52
Fat	3.66	3.66	3.66	4.04	4.04	4.04	3.45	3.45	3.45
Crude fibre	7.23	7.23	7.23	5.44	5.44	5.44	6.58	6.58	6.58
Lysine	0.92	0.92	0.92	0.87	0.87	0.87	0.96	0.96	0.96
Methionine	0.30	0.30	0.30	0.33	0.33	0.33	0.32	0.32	0.32
Calcium	2.50	2.50	2.50	3.52	3.52	3.52	4.51	4.51	4.51
Avail. Phosphorus	0.83	0.83	0.83	1.17	1.17	1.17	1.25	1.25	1.25
Ca: P	3:1	3:1	3:1	3:1	3:1	3:1	3.6:1	3.6:1	3.6:1

Vitamin and Trace mineral for each kg contained: Mn 40g, Fe 20g, Zn 18g, Cu 0.8g, I 0.62g, Co 0.09g and Se 0.04g, Pantothenic acid 1,000,000 IU, Cholecalciferol 1000 IU, Quinines 0.8g, Thiamine 0.6g and Riboflavin 2.4g, Folic Acid 0.4g, Biotin 0.02g, Ascorbic acid 10.0g, Choline Chloride 120g, Zinc Bacitracin 80.0g, Avatec 30.0g, ME=Metabolizable Energy

Table 2: Effect of calcium on performance of the hens

Parameters	Treatments A (2.5% Ca)	B (3.5% Ca)	C (4.5% Ca)	SEM
Number of eggs laid/hen	55.67[b]	61.89[a]	61.78[a]	0.21
Hen day production (%)	79.56[b]	88.37[a]	88.20[a]	0.31
Dozen eggs/hen	4.64[b]	4.64[b]	5.15[a]	0.02
Feed intake/hen (g/hen/day)	141.56[a]	138.22[b]	136.44[c]	0.35
Feed/dozen eggs (Feed conversion ratio)	2.13[a]	1.87[b]	1.79[c]	0.01
Feed cost per dozen eggs (₦)	286.17[a]	234.71[c]	240.40[b]	0.97
Mortality	0.00	0.00	0.00	0.00

[abc] = Means within each row that bear different superscripts differ significantly ($P < 0.05$)

Effect of Vitamin D_3 on performance of the hens

The result of the effect of vitamin D_3 levels in diets on the performance of hens is shown in Table 3. From the study, the diets significantly ($P < 0.05$) affected number of eggs laid per hen, hen-day production (HDP), dozen egg/hen, feed intake, feed/dozen egg (feed conversion) and feed cost/dozen egg while mortality was not affected. The hens fed the 2000 IU level of vitamin D_3 in diet had significantly ($P < 0.05$) higher number of eggs laid per hen, hen-day production and dozens of eggs laid per hen while those fed of 4000 IU and 6000 IU had significantly ($P < 0.05$) lower values. Hens fed with 6000 IU level of vitamin D_3 diets had the highest feed intake followed by the 4000 IU level, while hens fed 2000 IU level had significantly ($P < 0.05$) lower feed intake of 136.67g. The feed conversion (feed/dozen egg) and feed cost/dozen egg produced followed similar trend. There was no mortality observed during the period of study

Table 3: Effect of vitamin D_3 on performance of the hens

Parameters	2000 IU Vit. D_3	4000 IU Vit. D_3	6000 IU Vit. D_3	SEM
Number of eggs laid/hen	61.56[a]	58.89[b]	58.89[b]	0.21
Hen day production (%)	87.90[a]	84.09[b]	84.08[b]	0.31
Dozen eggs/hen	5.39[a]	4.91[b]	4.90[b]	0.02
Feed intake/hen (g/hen/day)	136.67[c]	138.22[b]	141.33[a]	0.35
Feed/dozen eggs (Feed conversion ratio)	1.80[c]	1.97[b]	2.02[a]	0.01
Feed cost per dozen eggs (₦)	236.38[c]	259.78[b]	265.12[a]	0.97
Mortality	0.00	0.00	0.00	0.00

[abc] = Means within each row that bear different superscripts differ significantly ($P < 0.05$)

Interactive effect of calcium and vitamin D_3 on performance of hens

The result of the interactive effect of different levels of calcium (2.5%, 3.5% and 4.5%) and Vitamin D_3 (2000 IU, 4000 IU, and 6000 IU) in diets on the performance of hens is shown in Table 4. From the study, the diets significantly ($P < 0.05$) affected number of eggs laid per hen, hen-day production (HDP), dozen egg/hen, feed intake, feed/dozen egg (feed conversion) and feed cost/dozen egg while mortality was not affected. The hens fed diet C (4.5% Ca) along with 2000 IU vitamin D_3 had significantly higher ($P < 0.05$) number of eggs laid per hen, highest HDP and highest dozens of eggs per hen while the hens fed diet A diet, containing 4000 IU had the lowest number of eggs, HDP and dozens of

eggs per hen. The birds fed the 'A' diet with 6000 IU of vitamin D_3 had the highest feed intake, while those fed diet 'C' with 4000 IU vitamin D_3 had the lowest feed intake of 135.67g. The feed conversion ratio (feed/dozen egg) significantly ($P < 0.05$) differed from each other, such that diet A with vitamin D_3 level of 4000 IU and 6000 IU were significantly poorer (having the highest of values of 2.16 and 2.17 respectively), while diet C with vitamin D_3 level of 2000 had the best feed conversion (recording the lowest value of 1.49).

The feed cost per dozen egg was however significantly ($P < 0.05$) higher for the A diets with vitamin D_3 at levels of 4000 IU and 6000 IU, while the least cost was obtained from diet C with 2000 IU vitamin D_3 (₦200.68). There was no mortality during the period of study.

Discussion

Effect of calcium on performance of the hens

The performance of the hens which were affected except for mortality, could be linked to the different levels of calcium in the diet. The hens fed diet B and C which performed better in terms of the number of egg laid per hen, hen-day production (HDP) and dozen egg per hen, was in agreement with Akinola and Iyomo (2018) who reported that hens performed better with regards to the number of egg laid per hen, hen-day production and dozens of eggs produced per hen when fed calcium levels of 3.5% and 4.5% in maize-soya diets. Also, Chandramoni *et al*. (1998), found that increase in the calcium level from 3.5% to 4.5% in the diet of hens was best for the performance of the birds in terms of number of egg laid per hen, hen-day production and dozen egg per hen.

The hens fed diet A which were observed to consume more feed which reduced significantly as the calcium level increased, was in agreement with Narvaez-Solarte *et al*. (2006) who reported that daily feed intake was decreased as the dietary calcium levels increased. However, Chandramoni *et al*. (1998) found that with increasing dietary calcium levels, the daily feed intake tended to be increased, but not significantly. However, the result obtained was contrary to the finding of Olver and Malan (2000) who observed that the dietary calcium levels did not influence the total feed intake during 16 to 80 weeks of age. This discrepancy may be attributed to differences in age of bird, dietary energy density and feeding levels of calcium. The decreasing feed consumption observed in this study as the level of Ca in diet increased will be beneficial to the farmer since it also resulted in higher HDP with least cost of feed per dozen egg produced.

The significant effect of calcium in diets on feed conversion ratio in this study is contrary to the findings of Kussakawa *et al* (1998) who did not find any effect of different calcium levels on feed conversion ratio when calcium level was increased in the feed of the hens from 3.0 to 4.0%. This may be as a result of the different calcium ingredients used which included calcite limestone and marine calcium in a maize-soya diet n their study, whereas, this study had bone meal and limestone as the calcium components of the feed and cassava root meal as the energy source for the 2.5 and 4.5% Ca diets.

The feed cost per dozen egg which had the highest value when diet A was fed to hens, implied that diet A will not be the best feed for laying hens in the humid tropics since their hen-day production was the least compared to the other treatment groups. Diet B which had the least cost and highest hen-day production will be the best for farmers in the humid tropics. However, diet C, although with significantly higher feed

Table 4: Interactive effect of calcium and vitamin D_3 on performance of the hens

Parameters	A			B			C			SEM
	2.5% Ca			3.5% Ca			4.5% Ca			
	2000 IU	4000 IU	6000 IU	2000 IU	4000 IU	6000 IU	2000 IU	4000 IU	6000 IU	
No of Eggs/hen	56.33^{e}	54.33^{f}	56.33^{e}	61.33^{c}	62.67^{b}	61.67^{bc}	67.00^{a}	59.67^{d}	58.67^{d}	0.73
Hen Day Prod. (%)	80.47^{e}	77.57^{f}	80.47^{e}	87.57^{c}	89.50^{b}	88.03^{bc}	95.67^{a}	85.20^{d}	83.73^{d}	1.04
Dozen Eggs/hen	4.69^{f}	4.53^{g}	4.69^{f}	5.11^{c}	5.22^{b}	5.13^{c}	5.58^{a}	4.97^{d}	4.89^{e}	0.10
Feed Intake/hen (g/hen/day)	138.00^{c}	140.33^{b}	146.33^{a}	136.00^{de}	138.67^{bc}	140.00^{b}	136.00^{de}	135.67^{e}	137.67^{cd}	0.64
Feed/dozen eggs (FCR)	2.05^{b}	2.16^{a}	2.17^{a}	1.86^{e}	1.86^{e}	1.90^{d}	1.49^{f}	1.90^{d}	1.97^{c}	0.38
Feed cost/dozen eggs	275.43^{b}	290.81^{a}	292.26^{a}	233.02^{f}	232.45^{f}	238.64^{e}	200.68^{g}	256.07^{d}	264.45^{c}	5.63
Mortality	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

^{abcdefg} = Means within each row that bear different superscripts differ significantly ($P < 0.05$)

cost per dozen egg than diet B could also be recommended/used by farmers since they also recorded higher hen-day production. This result is in line with Akinola and Iyomo (2018) who recorded highest hen-day production with corresponding lower cost of feed per dozen egg when laying hens were fed with diet containing 4.5% calcium. The absence of mortality in this study throughout the study period showed that increasing the Ca and vitamin D_3 levels in the diet for the laying hens is not detrimental to egg production.

Effect of vitamin D_3 on performance of the hens

The diet with 2000 IU vitamin D_3 in this study which resulted in significantly higher number of eggs laid per hen, hen-day production and dozen egg per hen was in agreement with Hamilton (1980), who observed that inclusion of vitamin D_3 in the diet of laying hen resulted to increased number of eggs laid per hen, hen-day production and dozen egg per hen. Nevertheless, this result was not in agreement with Browning and Cowieson (2014), who reported that no significance difference was observed in layer performance in number of eggs laid per hen, hen-day production and dozen egg per hen when the birds are fed with different levels of vitamin D_3 (up to 10,000 IU/kg feed). The result is also contrary to the finding of Mattila *et al*. (2004), who stated that vitamin D_3 in the diet of laying hens had no effect on number of eggs laid per hen, hen-day production and dozen egg per hen. The differences in results might be as a result of differences in geological zone, breed of hen, the cassava diet used in this case etc.

The hens fed the 6000 IU vitamin D_3 diet which were observed to have highest feed intake, feed conversion ratio and feed cost per dozen egg, which reduced significantly as the vitamin D_3 level in the diet reduced, was not in agreement with Hamilton (1980) who observed that increment of vitamin D_3 in the diet of laying hens promoted better feed conversion ratio. The 6000 IU vitamin D_3 inclusion which gave the highest feed cost per dozen egg implied that including 6000 IU of vitamin D_3 alone in diet of laying hens will not be useful to farmers in the humid tropics because it will make the farmer incurred more cost per dozen egg produced since the hens had higher feed intake, produced lesser number of eggs and had poor hen-day production. However, using lower levels of vitamin D_3 (2000 IU) alone in cassava diet for layers should be practiced by farmers since it resulted in better performance in terms of number eggs produced, HDP, dozen egg laid per hen and feed cost.

Interactive effect of calcium and vitamin D_3 on performance of hens

Birds fed diet C (containing 4.5% calcium) combined with 2000 IU vitamin D_3 which was observed to perform best in terms of number of eggs laid per hen, hen-day production and dozen egg per hen was not in agreement with Keshavarz and Nakajima. (1993), who reported that increasing dietary calcium levels and vitamin D_3 supplementation did not affect number of eggs laid per hen, hen-day production and dozens of egg per hen. Roland and Bryant (1994) and Castillo *et al.* (2004) also reported that there was no additional improvement in number of eggs laid per hen, hen-day production and dozen egg per hen when the dietary calcium was increased more than 3.5%.

The hens fed diet A with 6000 IU vitamin D_3 which had the highest feed intake and the hens fed diet C with 4000 IU vitamin D_3 which had the lowest value, was contrary to Bar *et al.* (2002) who found that feed intake

were not affected when the calcium content of the diet was increased from 3.6 to very high level of 4.9% of the diet in Lohmann Brown hens from 66 to 78 weeks of age, but their diet was a maize-soya bean meal diet while this study used cassava-based diets. The birds ate more diet A (2.5, 3.5 and 4.5 % Ca) along with 2000, 4000 and 6000IU vitamin D_3 and produced less number of eggs, despite having the highest feed cost/dozen egg which will lead to a loss to the farmer. Thus, it is not advisable for farmers to feed birds with diet A in combination with these levels of vitamin D_3. Nevertheless, the birds that were fed diet C with 2000 IU vitamin D_3 recorded better feed conversion ratio (least) and lower feed cost per dozen, which implied that if a farmer uses this particular feed for commercial laying hen, the birds are going to eat less of his feed and produced more eggs, higher HDP, dozens of eggs and lower feed cost per dozen egg produced.

Conclusion

This study revealed that diets B (3.5%), C (4.5%) and the 2000 IU vitamin D_3 level were better in terms of the performance of the hens (number of eggs laid per egg, HDP, and dozen egg per hen) when used alone (singly) in the diets. Nevertheless, diet C with 2000 IU vitamin D_3 level is recommended for farmers when Ca and vitamin D_3 are used together since it had the best performance, feed conversion to eggs and least cost of production when the interactive effect of Ca and vitamin D_3 was studied.

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References

Aduku, A. O. 1993. *Tropical Feedstuff Analysis Table*. Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University Zaria, Nigeria

Akinola, L. A. F. and Iyomo, E. 2018. Egg quality analysis and performance of laying hens fed different levels of calcium. *Nigerian Journal of Animal Production*, 45(1): 172-182.

Akinola, L. A. F. and Oruwari, B. M. 2007. Response of laying hens to total dietary replacement of maize with cassava. *Nigerian Journal of Animal Production*, 34(2): 196-202.

Bar, A., Razaphkovsky A. V, and Vax E. 2002. Re-evaluation of calcium and phosphorus requirements in aged laying hens. *British Poultry Science*. 43:261-169

Browing, L. C and Cowieson, A. J. 2014. Vitamin D fortification of eggs for human health. Journal of Science, Food and Agriculture. 94:1389 - 1396

Buitrago, J. A., Ospina, B., Gil, J. L. and Aparicio, H. 2002. Cassava root and leaf meals as the main ingredients in poultry feeding: Some experiences in Columbia. 523 -541

Calpe C. A. 1991. Roots, tubers and plantains: Recent trends in production, trade and use. Proceedings of the FAO Expert Consultation on the use of Roots, Tubers, Plantains and Bananas for Animal Feed; Cali, Colombia: CIAT. p.11-40.

Castillo, C., Cuca, M., Pro, A., González,

M. and Morales, E. 2004. Biological and economic optimum level of calcium in White Leghorn laying hens. *Poultry Science*. 83:868-872.

Chandramoni, S. Jadhao, B. and Sinha, R. P. 1998. Effect of dietary calcium and phosphorus concentrations on retention of these nutrients by caged layers. *British Poultry Science*. 39:544-548.

Combs, G. F., Jr. 1998. Vitamin D., The Vitamins: Fundamental Aspects in Nutrition and Health. 2nd ed. G. F. Combs, Jr., Academic Press, San Diego, California. Pp. 156-186 n

Driver, J. P., Pesti, G. M., Bakalli, R. I. and Edwards, H. M. Jr. 2005. Calcium requirements of the modern broiler chicken as influenced by dietary protein and age. Poultry Science. 84:1629-1639.

Egena, S. S. A. 2006. Effect of different hydrocyanic acid consumption on nutrient digestibility in broilers fed cassava flour meal. Proceeding of 11th Annual Conference of Animal Science Association of Nigeria (ASAN), Sept. 18 – 21st, 2006, IAR&T Ibadan, Nigeria

Fleming, R. H., Mccormack, H. A. Mcteir, L. and Whitehead, C. C. 2004: Incidence, pathology and prevention of keel bone deformities in the laying hen. Broiler Poultry Science. 45, 320-330.

Fleming, R. H., Mccormack, H. A. Mcteir, L. and Whitehead, C. C. 2006. Relationships between genetic, environmental and nutritional factors influencing osteoporosis in laying hens. *Poultry Science*, 47, 742-755.

Hamilton, R. M. G. 1980. The effects of dietary phosphorus, vitamin D3 and 25-hydroxyvitamin D3 levels on feed intake, productive performance, and egg and shell quality in two strains of force-molted white Leghorns. *Poultry Science*; 59:598-604

Kasim S., B. L. Blake and X. Fan. 2006. The role of dopamine receptors in the neurobehavioral syndrome provoked by activation of L-type calcium channels in rodents. *Developmental Neuroscience*. 28:505-517.

Keshavarz, K. and Nakajima, S. 1993. Re-evaluation of calcium and phosphorus requirements of laying hens for optimum performance and eggshell quality. *Poultry Science*. 72:144-153.

Korver, D. 2005. Research, analytical techniques and practical experiences using HyD™. In: Arkansas Nutrition Conference, Arkansas. pp. 12.

Kussakawa, K. C. K., Murakami, A. E. and Furlan, A. C. 1998. Combinations of calcium sources in diets of laying the final stage of production and after molting. *Brazilian Journal of Animal Science*. 27 (3): 572-578.

Leeson, S. and Summers, J. D. 2005. *Commercial Poultry Nutrition* 3rd Edition. University Books Guelph, Ontario, Canada

Mattila, P., Valaja, J., Rossow, L., Venäläinen, E. and Tupasela, T. 2004. Effect of vitamin D_2- and D_3-enriched diets on egg vitamin D content, production, and bird condition during an entire production period. *Poultry Science*. 83:433-440.

Narvaez-Solarte, W., Rostagno, H. S., Soures, P. R., Uribe-Velasquez, L. F. and Silva M. A. (2006. Nutritional requirement of calcium in white laying hens from 46 to 62 weeks of age. *International Journal of Poultry Science*. 5:181-184

NRC, 1994. National Research Council. Nutrient Requirements of Poultry. 9th rev. ed. National Academy Press, Washington DC. USA

Okoli A. 2008. Nigeria now world's highest producer of cassava. Available from: www.vanguardngr.com.

Okoli, L. C. and Udedibie, A. B. I. 2000. Effect of oil treatment and storage temperature egg quality. *Journal of Agricultural Rural Development*, 1: 55-60.

Olugbemi, T. S., Mutayoba, S. K and Lekule, F. P. 2010. Effect of moringa (*Moringa oleifera*) inclusion in cassava based diets fed to broiler checks. International Journal of Poultry Science. 9(4):363 – 367

Olver, M. D. and Malan. D. D. 2000. The effect of choice-feeding from 7 weeks of age on the production characteristics of laying hens. *South African Journal of Animal Science*. 30:110-114.

Oruwari B. M., Anibo A. O. and Nkanta D. M. 2003. Effect of replacing maize with cassava/brewers dried yeast blend cassava yeast on performance of broiler chicks and feed cost in Southern Nigeria. *Nigerian Journal of Animal Production*, 30(2): 168-178.

Pastore, S. M., Gomes, P. C., Rostagno, H. S., Fermando, L., Albino, T., Calderano A. A., Vellasco, C. R., Viana, G. S. and Almeida, R. L. 2012. Calcium levels and calcium: available phosphorus ratio in diets for white egg layers from 42-58 weeks of age. *Revista Brasileira de Zoootecnia*. 41(12), 2424-1432

Peixoto R. R, Rutz F. 1988. Fontes de cálcio para poedeiras comerciais. I. Calcários "Matarazzo", "Trevo Filler" and "Trevo Dolomítico". Revista Brasileira de Zootecnia. (1):17-29.

Pelicia, K.., Garcia, E. A., Faitarone, A. B. G., Silva, A. P., Berto, D. A., Molino A. B. and Vercese, F. 2009. Calcium and Available Phosphorus Levels for Laying Hensin Second Production Cycle. *Brazilian Journal of Poultry Science*.11: 39 – 49

Rennie, J. S. and Whitehead, C. C. 1996. Effectiveness of dietary 25-and1-hydroxy colecalciferol i n combating tibial dyschondroplasia in broiler chickens. *Brazilian Poultry Science*. 37:413421.

Rennie, J. S., Fleming, R. H., McCormack, H. A., McCorouodale, C. C. Whitehead, C. C. 1997. Studies on effects of nutritional factors on bone structure and osteoporosis in laying hens. *Brazilian Poultry Science*. **38**, 417-424.

Roland, D. A. and Bryant M. M. 1994. Influence of calcium on energy consumption and egg weight of commercial leghorns. *Journal of Applied Poultry Resource*. 3: 184-189.

Sandilands, V., Moinard, C., Sparks, N. H. C. 2009. Providing laying hens with perches: fulfilling behavioral needs but causing injury? *Brazilian Poultry Science*. **50**, 395-406.

Smith H. 2003. Cassava as substitute for cereals in livestock rations.

RADA. Available from: http://www.radajamaica.comjm/tech_articles.asp?section=technical&ID=46

Stupak, M., Vandeschuren, W., Gruissem, N. and Zhang, P. 2006. Biotechnological approaches to cassava protein improvement. Trends Food Science and Technology, 17:634 - 641

Tewe, O. O. 1994. Indices of Cassava Safety for Livestock Feeding: Being Paper in International ACTA Horticulture Workshop on Cassava Safety. IITA Ibadan pp: 241-248.

Ukachukwu, S. N. 2005. Studies on the nutritive value of composite cassava pellets for poultry: chemical composition and metabolizable energy. Livestock Research for Rural Development, 17(11)

Whitehead, C. C. 2004. Overview of bone biology in the egg laying hen. Poultry Science. 83:193-199.

Whitehead, C. C. and Fleming, R. H. 2000. Osteoporosis in cage layers. Poultry Science 79: 1033–1041.

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