Original Research

Effect of Calcium Pidolate on Egg Production and Egg Quality during Last Phase of Production Cycle with Reducing Levels of Inorganic Calcium

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Abstract

This study was undertaken to evaluate the effect of calcium pidolate supplementation on egg production and quality during the last phase of production cycle with reducing levels of inorganic calcium. 600 (BV 300 strain) layer birds of age 55 weeks were randomly divided into six equal groups with four replicates. Group A, C and E received diet with calcium level at 4%, 3%, 2% respectively while, group B, D and F received diet with calcium level at 4%, 3%, 2% respectively along with calcium pidolate supplementation @ 500 g/ ton of feed. The birds from group A recorded better performance with respect to total egg production, percent egg production, feed conversion ratio, total number of damaged eggs, hen house production and hen day production. The birds from group B recorded lowest number of broken eggs indicating calcium pidolate supplementation helped in reducing the downgraded eggs. Reducing calcium levels had detrimental effect on the health of birds. However, calcium pidolate supplementation was not useful in reducing the mortality. Different levels of calcium in the diet with or without calcium pidolate supplementation had no negative impact on the overall egg quality. Supplementation of calcium pidolate did not improve the eggshell quality. The tibia ash and tibia calcium percentage were the highest in birds from group A. Also, group A recorded the highest net profit per egg received which was Rs. 0.48. Thus, overall results conclude that using calcium at 4% level in the layer diet during last phase of production recorded better performance and profits. Calcium pidolate supplementation was unable to overcome the effects of reduced level of calcium in the layer diet during last phase of production cycle.

Key words: Calcium Pidolate, Organic Calcium, Reducing Calcium

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Introduction

Eggshell quality is one of the most important issues in poultry industry, influencing the profitability of egg production and hatchability. Poor eggshell quality has been a major economic concern to commercial egg producers with serious economic losses due to levels of downgraded eggs ranging from 6% to 20% (Roland, 1988; Keshevarz *et al.*, 1993; Hunton, 2005). The shell strength decreases with the aging of laying hens (Lavelin *et al.*, 2000). This is due to increase in the size of egg to a constant amount of deposited shell (Nys, 1986) and changes in metabolism leading to reduction in the capacity of intestinal absorption of calcium for laying hens (Bar *et al.*, 1999).

Calcium requirement of a laying hen is 4 - 6 times that of a non-laying hen, only 50 - 60% of dietary calcium is actually used in shell formation, rest of 30- 40% of calcium is derived from medullary bones. The high rates of bone resorption during lay result in bone weakness in layers by the end of their production cycle (Whitehead, 2004). Egg producers primarily use oyster shell grit and limestone powder as dietary sources of calcium for layers. Considerably higher levels of dietary calcium (4% or more) have been suggested for modern layers during the last phase of production cycle in order to compensate for higher calcium requirements. However, merely increasing the levels of calcium in diet does not guarantee improvement in the egg production and eggshell quality, which is due to reduction in calcium absorption. Hence, the absorption and utilization of calcium should be ensured by altering the traditional calcium sources.

Calcium pidolate is an organic source of calcium. According to research done in the French National Centre of Veterinary and Animal Studies (CNEVA) calcium pidolate in layer diet reduces the number of downgraded eggs and improves bone strength (Price, 2012). Calcium pidolate is also known as pyrrolidone carboxylic acid (PCA) calcium Salt. In calcium pidolate, the calcium ion (13%) is bound to two molecules of Pyrrolidone carboxylic acid (87%) that act as protein supports (Laurenceau *et al.*, 2011). Pyrrolidone carboxylic acid is a precursor of amino acids in intestinal cells viz. arginine and proline, which are fundamental in the binding process of calcium (Price, 2012). The protein constituents guarantee better intestinal absorption, easy circulation in the blood and excellent tissue binding. As the age advances, the hen is unable to absorb adequate quantity of calcium from intestine and mobilize enough amounts from bones for egg shell development. Hence, it is necessary to replenish the calcium in bones by supplementing calcium at higher levels in the diet or by enhancing the absorption of calcium. Inorganic sources of calcium are absorbed up to 10 - 30% depending on pH of the gut. However, calcium pidolate can get absorbed up to 95% as it is pH independent (Price, 2012).

Hence, it is thought worthwhile to evaluate the effect of calcium pidolate on performance of layers in terms of egg production and egg quality especially during the last phase of the laying cycle.

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Materials and Methods

Experimental Hens, Housing and Diets

The biological trial was conducted on 600 (BV 300 strain) layers for 21 weeks (from 55th till 75th weeks) in the Department of Poultry Science, Bombay Veterinary College, Mumbai. The layers were randomly divided into six equal groups with four replicates. All the birds were reared in three tier California cage system with five birds per compartment. The replicates were distributed in such a manner so as to nullify the row and tier effect. All the groups were reared in ideal and identical management conditions throughout the trial period. Throughout the trial period, 16 hours light was provided to the birds.

Treatments

Each group received one of the following treatments:
Group A – Control – Diet with inorganic sources of calcium with calcium level at 4%
Group B – Diet similar to group A + Calcium pidolate @ 500 g/ T
Group C – Diet with inorganic sources of calcium with calcium level at 3%
Group D – Diet similar to group C + Calcium pidolate @ 500 g/ T
Group E – Diet with inorganic sources of calcium with calcium level at 2%
Group F – Diet similar to group E + Calcium pidolate @ 500 g/ T

Data Collection

The observations were recorded on daily number of egg production, weekly feed consumption, daily number of broken eggs produced, damaged eggs produced (thin-shelled, misshaped, shell-less and eggs with uneven calcium deposition etc.) and mortality from these observations, feed conversion ratio on egg number basis, average percent egg production, hen day egg production and hen house egg production were calculated. Egg quality parameters such as egg weight, shape index, albumin index, yolk index, haugh unit and shell thickness were recorded from the start of the trial and at weekly intervals. The tibia ash and tibia calcium content were estimated using pooled tibia samples from each group at the start and end of the trial. The economics of production was worked out considering prevailing cost of the inputs and selling price of eggs.

Statistical Analysis

The data were subjected to statistical analysis for all the parameters as per Snedecor and Cochran (1994), considering groups/ treatments as the only variable and using Completely Randomized Design.

Results and Discussion

The result of calcium pidolate supplementation on egg production and egg quality during last phase of production cycle with reducing levels of inorganic calcium is presented in Table 1.

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Table 1: Overall performance of the birds

Parameters	A	B	C	D	E	F	P value
Egg Production Parameters							
No. of birds	100	100	100	100	100	100	NA
Mortality No.	1	0	5	5	7	6	NA
No. of eggs produced	13313	13057	12942	12790	11164	11663	NA
Percent egg production (%)[1]	$91.48^{a}\pm0.66$	$88.82^{a}\pm0.58$	$90.60^{a}\pm0.73$	$89.02^{a}\pm0.70$	$78.21^{b}\pm1.63$	$82.64^{c}\pm1.91$	**
Feed consumed per bird per day (g)[1]	117.38±0.64	115.89±0.72	117.85±0.88	116.67±1.00	114.87±2.43	116.43±2.56	NS
Feed conversion ratio[1]	$1.54^{a}\pm0.01$	$1.57^{a}\pm0.01$	$1.56^{a}\pm0.02$	$1.57^{a}\pm0.02$	$1.77^{b}\pm0.03$	$1.70^{c}\pm0.03$	**
No. of broken eggs produced	607	586	783	721	1058	1459	NA
No. of damaged eggs produced	101	105	185	194	233	299	NA
HHEP for 21 weeks	133.13	130.57	129.42	127.9	111.64	116.63	NA
HDEP for 21 weeks	134.47	130.57	136.23	134.63	120.04	124.07	NA
Egg Quality Parameters							
Egg weight (g)[1]	62.18±0.46	62.30±0.47	62.60±0.50	62.66±0.38	62.13±0.43	63.43±0.34	NS
Shape index[1]	$75.81^{ab}\pm0.24$	$75.19^{bc}\pm0.20$	$75.86^{a}\pm0.24$	$75.00^{cd}\pm0.30$	$74.53^{de}\pm0.24$	$74.24^{e}\pm0.21$	**
Albumin index[1]	$9.26^{a}\pm0.29$	$8.94^{ab}\pm0.21$	$9.22^{a}\pm0.25$	$8.37^{b}\pm0.23$	$8.75^{ab}\pm0.21$	$8.55^{b}\pm0.23$	*
Yolk index[1]	$44.32^{a}\pm0.27$	$44.33^{a}\pm0.30$	$43.55^{ab}\pm0.32$	$43.31^{b}\pm0.27$	$43.50^{b}\pm0.29$	$43.50^{b}\pm0.24$	*
HAU [1]	$84.67^{a}\pm1.16$	$83.28^{ab}\pm0.87$	$84.38^{a}\pm1.14$	$80.77^{c}\pm0.99$	$82.49^{abc}\pm0.89$	$81.45^{bc}\pm1.11$	*
Shell thickness (mm)[1]	$0.342^{a}\pm0.005$	$0.343^{a}\pm0.004$	$0.333^{a}\pm0.005$	$0.333^{a}\pm0.004$	$0.292^{b}\pm0.005$	$0.296^{b}\pm0.004$	**
Economics							
Net profit per egg (Rs.)	0.48	0.39	0.43	0.37	-0.01	0.1	NA

*[1]Mean ± Standard error; Those means with common superscript do not differ significantly; NA Not applied; NS Not significant;** (P<0.01);* (P<0.05)*

Percent Egg Production

The differences in the percent egg production from different groups were statistically significant (P<0.01). Providing diet with 4% calcium level is useful in recording higher percent egg production during last phase of production cycle. Supplementation of calcium pidolate did not improve the percent egg production at 4% and 3% calcium level in diet. However, at 2% calcium level supplementation of calcium pidolate showed better results. These findings are in accordance with the work of Safaa *et al.* (2008) who observed an increase in calcium intake and improved egg production from 71.2% to 74.9% (P< 0.001) in 3.5% and 4% calcium level groups, respectively in brown egg laying hens at the late phase (from 58 to 73 weeks) of production. Nascimento *et al.* (2014) observed quadratic effect (P<0.05) of calcium levels in egg production with better results at 4.12%, 4.09% and 4.14%, respectively on performance, egg quality and bone strength of hens in the second production cycle (of 80 weeks). However, in calcium Pidolate group Isaac *et al.* (2015) observed significantly increased egg production by 5% (P<0.05), which is not in accordance with our results except at 2% calcium level.

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Total Number of Broken Eggs

The differences in the total number of broken eggs produced by different groups were statistically significant (P<0.01). The data revealed increase in the number of broken eggs with relative reduction in the diet calcium level. Providing diet with 4% and 3% calcium level along with calcium pidolate effectively reduced number broken eggs. These findings are in accordance with the work of Agblo *et al.* (2011) who observed average 27% decrease in downgraded eggs, when calcium pidolate is supplemented through drinking water to laying hens (at 62 weeks) and Isaac *et al.* (2015) observed significantly reduced downgraded eggs by 25% (P<0.05) after incorporation of calcium pidolate and oyster shell. However, at 2% calcium level, calcium pidolate supplementation did not have useful effect in reducing the number of broken eggs.

Number of Damaged Eggs

The differences in the total number of damaged eggs produced by different groups were statistically significant (P<0.01). Providing diet with 4% calcium level is beneficial in recording lower number of damaged egg production during last phase of production cycle. Supplementation of calcium pidolate did not improve the damaged egg number at all the three levels of calcium used in this trial.

Feed Conversion Ratio on Egg Number Basis

The differences in the feed conversion ratio from different groups were statistically significant (P<0.01). Reducing diet calcium level led to increase in the feed conversion ratio. Supplementation of calcium pidolate did not improve feed conversion ratio with exception at 2% calcium level, where improvement in feed conversion ratio was observed. Hence, it can be concluded that providing diet with 4% calcium level is beneficial in recording better feed conversion ratio during last phase of production cycle. Pelicia *et al.* (2009) observed that feed conversion ratio was not significantly influenced by the linear increase in calcium intake (3%, 3.5%, 4% and 4.5%) and available phosphorous levels of laying hens in second production cycle (between 90 to 108 weeks). These findings are in accordance with our study except at 2% calcium level. However, in calcium pidolate group Isaac *et al.* (2015) observed significantly decrease in feed conversion ratio by 10% (P<0.05) through decrease in downgraded eggs and increase in total egg production. These findings are contradicting with our results except at 2% calcium level.

Mortality (No.)

In total 24 birds died during the entire trial period and most of them were from the groups receiving 3% and 2% calcium level diets. Hence, it may be concluded that reducing diet calcium level during the last phase of production cycle had detrimental effect on the health of birds. Calcium pidolate supplementation to these groups was ineffective in reducing mortality. However, the differences in the mortality number

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observed in different groups were statistically non-significant. Similarly, the numbers of dead birds were not significant, as gradually birds got adjusted to reduced level of calcium in the diet.

Tibia Ash and Tibia Calcium Content

The tibia ash percentage recorded from the pooled samples of birds sacrificed at the start of the trial was highest. In general it was observed that the tibia ash percentage from birds receiving different treatments reduced at the end of the trial. Further, supplementation of calcium pidolate did not have any influence on the tibia ash percentage. The tibia calcium percentage recorded from birds sacrificed at the start of the trial was highest. Tibia calcium percentage obtained from birds from different groups reduced as the trial progressed. Further, significant reduction in the tibia calcium percentage was evident when calcium level was reduced to 2%. However, supplementation of calcium pidolate helped the birds in retaining more calcium in the tibia than the birds from non-supplemented counterparts. The values pertaining to calcium content of the tibia ash of the birds at start and the end of the trial from the birds from different groups are presented in Table 2.

Table 2: Average tibia ash and tibia calcium content (%)

Parameters	Groups						
	At the Start of Trial	A	B	C	D	E	F
Total ash (DM basis) %	49.62	48.18	44.03	44.82	47.68	47.48	46.03
Calcium (DM basis) %	7.52	7.28	7.01	6	7.39	5.82	6.21

Shape Index

The differences in the average shape index from different groups were statistically significant (P<0.01). The shape index of eggs produced by birds from different groups was well within the normal range and was equally suitable for transportation and acceptability by the consumer. Safaa *et al.* (2008) observed that increase in calcium intake (at 3.5% and 4%) and source of calcium had no effect on shape index of eggs from brown egg laying hens in the late phase (from 58 to 73 weeks) of production. These results are in accordance with our results except at 2% calcium level.

Albumin Index

The differences in the average albumin index from different groups were statistically significant (P<0.05). Reduction in calcium level in the diet and supplementation of calcium pidolate both had negative effect on the egg albumin index. These results are contradicting with the findings of Al-Zahrani *et al.* (2015) who observed that albumin quality was higher when diet was supplemented with calcium pidolate and 25-hydroxycholecalciferol in commercial laying hens (of 21 to 50 weeks).

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Yolk Index

The differences in the average yolk index from different groups were statistically significant (P<0.05). Different levels of calcium in the diet with or without supplementation of calcium pidolate had no negative impact on yolk index of eggs. Safaa *et al.* (2008) observed that increase in calcium intake (3.5% and 4%) and source of calcium had no effect on yolk index of eggs from brown egg laying hens in the late phase (from 58 to 73 weeks) of production. Pelicia *et al.* (2009) observed that yolk index was not influenced by the linear increase in calcium intake (3%, 3.5%, 4% and 4.5%) and available phosphorous of laying hens in second production cycle (between 90 to 108 weeks). The findings of the present study are in accordance with the above results except at 2% calcium level.

Haugh Unit

The differences in the average haugh unit from different groups were statistically significant (P<0.05). The overall egg quality measured in terms of haugh unit from eggs produced by birds from all the groups were well within the acceptable range. Supplementation of calcium pidolate did not improve the haugh unit. These findings are in accordance with the work of Nascimento *et al.* (2014) who observed that different calcium levels (2.85%, 3.65%, 4.45% and 5.25%) had no effect on the Haugh unit of egg from hens in the second production cycle (of 80 weeks). However, results contradicting with our findings were observed by Al-Zahrani *et al.* (2015) observed that albumin quality was higher when diet was supplemented with calcium pidolate and 25- hydroxycholecalciferol commercial laying hens (of 21 to 50 weeks).

Egg Shell Thickness

The differences in the average shell thickness from different groups were statistically significant (P<0.01). The shell thickness of eggs produced by birds receiving 4% calcium in the diet was found to be optimum for the age of birds. The shell thickness of eggs produced by birds receiving 3% calcium in the diet was also acceptable. However, further reduction in the calcium level to 2% has resulted in unacceptable reduction in shell thickness of eggs. Further, It was also recorded that supplementation of calcium pidolate did not show improvement in egg shell quality irrespective of diet calcium level. These findings are in accordance with the work of Safaa *et al.* (2008) who observed an increase in calcium intake improved egg shell thickness from 0.342 mm to 0.351 mm (P< 0.01) in 3.5% and 4% calcium level groups respectively in the late phase (from 58 to 73 weeks) of production. Nascimento *et al.* (2014) observed linear increase in eggshell thickness (P<0.05) as the level of calcium in the diet increased (2.85%, 3.65%, 4.45% and 5.25%) in hens in the second production cycle (of 80 weeks). However, results contradicting with our findings were observed by Al-Zahrani *et al.* (2015) who noted shell quality was generally not improved by the addition of calcium pidolate with or without 25- hydroxycholecalciferol to a complete layer diet and some of the

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treatments resulted in small but significant reductions in shell quality of commercial laying hens (of 21 to 50 weeks).

Economics of Egg Production

The cost of feed for calcium pidolate supplemented groups was higher than their non-supplemented counterparts by Rs. 0.30 per Kg. From the data it is evident that the net profit per egg in groups A and C were higher than their calcium pidolate supplemented counterparts group B and D. However, group F with calcium pidolate supplementation generated higher net profits than its non-supplemented counterpart group E.

Conclusion

Thus, the overall results of the experiment concluded that using calcium at 4% level in the diet recorded better performance and profits. The results also indicated that use of calcium pidolate recorded lower number of broken eggs. However, supplementation of calcium pidolate did not help the birds to record overall improvement in the parameters studied in this trial. The effects of reduction in the calcium levels in the diet of birds were evident in lower production performance and supplementation of calcium pidolate did not prove to be effective in overcoming the effects in terms of productivity and profitability of egg production during the last phase of egg production.

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