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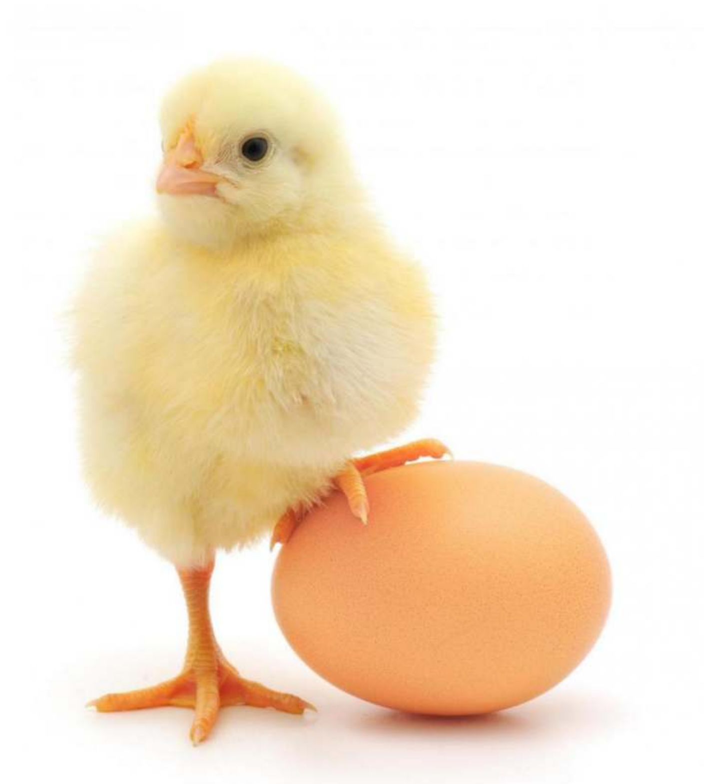

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ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorijps@gmail.com

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Performance Comparison and Lysine Requirements of Seven Commercial Brown Egg Layer Strains During Phase Two

P. Gunawardana, D.A. Roland and M.M. Bryant
Department of Poultry Science, Auburn University, Auburn, 36849, Alabama, USA

Abstract: This study was a 3x7 factorial arrangement with 3 lysine levels (0.828, 0.747 and 0.680) and 7 commercial brown egg layer strains. The objective of this experiment was to determine the effect of increasing dietary lysine on performance, egg composition, egg solids, egg quality and profits in 7 commercial brown egg l ayer strains and to determine the lysine requirement during phase 2 (from 39-52 week of age). This experiment lasted 14 weeks. Seven strains of hens (n = 240 of each strain) at 39 week of age were randomly divided into 21 treatments (8 replicates of 10 birds/treatment). The results showed that there were no interactions between lysine and strain on any parameter. Lysine had significant effects on feed consumption, egg production, egg mass, feed conversion, egg weight, egg shell components, percent yolk and whole egg solids, albumen and yolk weight, egg specific gravity, yolk color and haugh units. There were significant strain effects on feed consumption, egg mass, feed conversion, egg weight, albumen and yolk components, whole egg solids, albumen and shell weight, egg specific gravity, body weight, shell color and haugh unit. Strain 1 had the best overall performance. All strains were laying 89.5-92.5% at 52 weeks of age. Average egg weight (39-52 week) was 63 g, varying from 61.5-63.6 g between strains. Average feed intake was 112.1 g/hen/day varying from 108-114 g/hen/day between strains. Average egg weight of hens fed diets containing the highest lysine level was 3.38 g heavier than hens fed the diets containing the lowest lysine level. Increasing dietary lysine from 0.680-0.828% significantly improved feed conversion from 2.03-1.91 g feed/g egg and increased egg mass from 54.0-59.30 g/hen/day. Average lysine intake of hens fed 0.828% level was 939 mg/hen/day varying from 907-964 mg/hen/day between strains. Because egg and ingredient prices often change, there can be no fixed dietary lysine level for optimal profits.

Key words: Brown layer strain, lysine requirement, shell color

INTRODUCTION

Brown-egg-laying hens predominate in many parts of the world and their use is growing in the USA and South American countries as well. Different brown strains have different production characteristics, egg components, egg solids and egg quality (Wu *et al.*, 2005a). Some strains may be beneficial for further processing such as dried and liquid egg production where as some strains may be beneficial for table egg production. Several commercial Brown-egg-layer strains are currently used by egg producers. There is a surprising lack of information on comparative nutrition and their response to various feeding strategies.

Protein (lysine) is a nutrient for laying hens representing a significant percentage of total cost of the diets. Liu *et al.* (2005) and Wu *et al.* (2005b) reported that increasing protein (lysine) level significantly affected egg production, egg weight, egg mass, feed consumption, feed conversion, egg specific gravity and body weight of hens. The requirement for amino acids, especially lysine of brown egg laying hens varies as functions of the rate of growth determined by the genotype and age (Hurwitz *et al.*, 1978). The various strains of hens, each with its own lysine requirement, are kept for extended periods during which the requirements may continuously change. Brown-egg strains produce considerably more egg mass and generally convert feed to egg mass more efficiently than white leghorns (Hurwitz *et al.*, 1978). So, it might be expected that their nutrient requirements are more exacting than white leghorns.

The amino acid content of diets affects the efficiency of protein utilization. Methionine is the first limiting amino acid in corn-soybean diets followed by lysine (Harms *et al.*, 2000). The ideal protein concept is often used in the formulation of diets. This concept assumes that all amino acids are in balance and are equally limiting (Barker, 2003; Vieira *et al.*, 2004). Although, the absolute requirements of amino acids may change in different practical situations, the ratio between amino acids should remain stable. Therefore, lysine is often used as the reference amino acid and the other essential amino acids such as TSAA are calculated by using the respective ratio to lysine. However, no estimates of the lysine requirements of different brown-egg layer strains have been made. It is important for commercial layer industry to know the nutritional requirements of laying hens at different ages. Hens are normally fed high lysine diets ranging from 0.828-0.956% during phase 2. Although, feeding high lysine diets can optimize performance, the cost of high protein diets and egg prices determine the level needed for optimal profits (Wu *et al.*, 2007). Therefore, it is important to know the response of hens (egg weight, egg production and feed consumption) above and below the lysine requirement to be able to determine the requirement for optimal profits as feed and egg prices change. Few if any studies have been conducted to compare responses to lysine across current brown-egg layer strains to determine lysine requirement during phase 2.

Egg quality has become an important aspect of egg marketing as retail outlets are now demanding very high standards for conventional internal and external quality characteristics. Throughout the world, preference for shell color in table eggs differs and is based mainly on the visual appearance of the egg. Although shell color has nothing to do with the internal quality of egg, many consumers throughout the world prefer brown eggs over white eggs (Odabasi *et al.*, 2007). Uniformity of color of brown eggs, together with a certain minimum depth of color are important considerations for consumers. Pale-shelled eggs are often deemed unacceptable causing some highly productive strains to be rejected. However, egg shell color between strains has received very limited or no research attention. Therefore, the objective of this experiment was to determine the effect of increasing dietary lysine on performance, egg composition, egg solids, egg quality, in 7 commercial brown egg layer strains and to determine the nutrients (lysine) requirements that allow for best performance in phase 2 (from 39-52 week).

MATERIALS AND METHODS

This study was a 3x7 factorial arrangement with three dietary lysine levels (0.828, 0.747 and 0.680) and seven commercial brown egg layer strains. The 7 brown commercial or experimental egg laying strains (obtained from Centurion poultry Inc.[1]) were identified as strains 1-7. Strain 5 was the Bovans Brown classic. Ingredients and nutrient composition of experimental diets are shown in Table 1. Feed and feed ingredient samples were analyzed for amino acids[2]. Dietary energy (2866 ME kcal/kg) was maintained the same in all diets. Diets were formulated according to the minimum nutrient requirements specified by NRC (1994). In this experiment, 7 brown egg laying strain of hens (total n = 1680) at 39 week of age were randomly assigned into 21 treatments (8 replicates of 10 hens per treatment). The trial lasted 14 weeks. Hens were housed two per cage in a 40.6x45.7 cm cage. Each replicate consisted of five adjoining cages. Replicates were equally distributed into upper and lower cage levels to minimize cage level effect. All hens were housed in an environmentally controlled house with temperature maintained as close to 26°C as possible. The house had controlled ventilation and lighting (16L:8D). All hens were supplied with feed and water *ad libitum*. Animal housing and handling procedures during experimentation were in accordance with guidelines of Auburn University's Institutional Animal Care and Use Committee (IACUC). Feed consumption was recorded weekly and calculated average daily feed consumption, egg production was recorded daily and egg weight and specific gravity were recorded once every two weeks. Egg weight and egg specific gravity were measured using all eggs produced during two consecutive days. Feed consumption was determined by subtracting the ending feed weight of each trough (each replicate) from beginning feed weight weekly. Egg specific gravity was determined using 9 gradient saline solutions varying in specific gravity from 1.060-1.100 in 0.005 unit increments (Holder and Bradford, 1979). Mortality was determined daily and feed consumption was adjusted accordingly. Body weight was obtained by weighing 3 hens per replicate at the end of the experiment. Egg mass (g of egg/hen per day) and feed conversion (g of feed/g of egg) were calculated from egg production, egg weight and feed consumption.

Egg components were measured using 3 randomly selected eggs from each treatment replicate at the middle and end of the experiment. Eggs were weighed and broken. The yolks were separated from the albumen. Before yolk weight was determined, the chalaza was removed by forceps. Each yolk was rolled

Table 1: Ingredients and nutrient content of the experimental diets

Ingredient (%)	Diet 1	Diet 2	Diet 3
Corn	70.91	67.9	64.35
Soy bean meal	16.9	19.5	22.4
Hard shell[1]	4.0	4.0	4.0
Limestone	5.1	5.1	5.1
Dicalcium phosphate	1.6	1.6	1.6
Poultry oil	0.5	1.0	1.6
NaCl	0.36	0.36	0.36
Vitamin Premix[2]	0.25	0.25	0.25
Mineral Premix[3]	0.25	0.25	0.25
DL-Methionine	0.008	0.03	0.07
Total	100	100	100
Calculated analysis			
ME (Kcal/kg)	2866	2866	2866
Crude protein	13.8	14.8	15.96
Ca	4.0	4.0	4.0
Available phosphorus	0.4	0.4	0.4
Na	0.17	0.17	0.17
Methionine + Cystine	0.51	0.56	0.62
Lysine	0.680	0.747	0.828

[1]Hard shell = large particle limestone (passing US mesh #4 and retained by US mesh #6) $CaCO_3$ supplied by Franklin Industrial Minerals, Lowell, FL. [2]Provided per kilogram of diet: Vitamin A (as retinyl acetate), 8,000 IU; cholecalciferol, 2,200ICU, vitamin E (as DL-α-tocopheryl acetate), 8 IU; vitamin B12, 0.02 mg; riboflavin, 5.5 mg; D-calcium pentothenic acid, 13 mg; niacin, 36 mg; choline, 500 mg; folic acid, 0.5 mg; vitamin B1 (thiamin mononitrate), 1 mg; pyridoxine, 2.2 mg; biotin, 0.05 mg; vitamin K (menadione sodium bisulfate complex), 2 mg. [3]Provided per kilogram of diet: manganese, 65 mg; iodine, 1 mg; iron, 55 mg; copper, 6 mg; zinc, 55 mg; selenium, 0.3 mg

on a blotting paper towel to remove adhering albumen. The shells were cleaned of any adhering albumen and dried for 5 days. Albumen weight was calculated by subtracting the weight of yolk and shell from the whole egg weight.

Three eggs from each treatment replicate were randomly collected at the middle and at the end of the experiment for measuring solids. The yolk and albumen were mixed and 5-6 g of homogenate was pipetted into an aluminum dish with weight recorded to 0.001 g. The sample was dried in an oven for 24 h at 40.5°C (AOAC, 1990) and then weighed. Three eggs which randomly selected from each treatment replicate were used to analyze yolk and albumen solid. After yolk was separated from albumen, three yolks and albumen per replicate were mixed separately. The procedure for analyzing albumen and yolk solid was the same as the procedure for whole egg solid content. Yolk color and haugh units were measured (3 eggs from each treatment replicate) at the middle and at the end of the experiment using an egg multi tester EMT-5200 (Robotmation, co, Ltd. Tokyo, Japan). Haugh units were calculated from the records of albumen height and egg weight using the formula:

$$HU=100 \log_{10} (H-1.7 W^{0.37}+7.56)$$

where:

HU = Haugh unit.
H = Height of the albumen.
W = Egg weight.

Shell color was measured (3 eggs of each treatment replicate) at the middle and at the end of the experiment using CHROMA METER CR-300 (Minolta co, Ltd. Osaka, Japan). The egg shell color reported as L^*, a^* and b^*. The L^* value represents lightness and ranges from 0-100, with 0 corresponding to black and 100 to white. Redness-greenness and yellowness-blueness, were measured by a^* and b^*, respectively.

Data were analyzed by ANOVA using proc mixed of Statistical Analysis System (SAS Institute, 2000) for a randomized complete block with a factorial arrangement of treatments. Dietary lysine and strains were fixed, whereas blocks were random. The factorial treatment arrangement consisted of three dietary lysine levels and seven strains. The following model was used to analyze the data:

$$Y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + P_k + \varepsilon_{ijk}$$

Where:

Y_{ijk} = Individual observation.
μ = Overall mean.
α_i = Dietary lysine effect.
β_j = Strain effect.
$K\beta_{ij}$ = Interaction between dietary lysine and strain.
P_k = Effect of block.
ε_{ijk} = Error component.

If differences in treatment means were detected by ANOVA, Duncan's multiple range test was applied to separate means. A significance level of P= 0.05 was used for analysis.

RESULTS AND DISCUSSION

Feed consumption: Increasing dietary lysine significantly increased feed consumption (Table 2). As dietary lysine increased from 0.680-0.828%, feed consumption increased by 3.02%. Strain also had a significant effect on feed consumption. Feed consumption of strain 1 was significantly lower than the other six strains (Table 2). Highest feed consumption occurred in strain 2 and 6. There were no significant differences in feed consumption among strains 3, 4 and 7. Although, lysine level and strain influenced feed consumption, there was no significant interaction between strain and dietary lysine on feed consumption.

Egg production: Increasing dietary lysine significantly increased egg production (Table 2). As dietary lysine increased from 0.680-0.828%, egg production linearly increased from 88.5-92.1, resulting in a 4.1% increase of egg weight (Table 2). However, neither strain nor interaction between dietary lysine and strain had a significant effect on egg production.

Egg mass: Both strain and dietary lysine had a significant effect on egg mass (Table 2). However, there was no significant interaction between strain and dietary lysine on egg mass. As dietary lysine increased, egg mass linearly increased by 9.85% from 53.9-59.3 g. Strain 1 had the highest egg mass and strain 4 had the lowest. There were no significant differences in egg mass among strain 1, 2, 3, 5 and 7.

Egg weight: Both dietary lysine and strain had a significant effect on egg weight (Table 2). However, there was no significant interaction between strain and dietary lysine on egg weight. Increasing dietary lysine increased egg weight by 5.54% from 61.02-64.40 g. Strain 4 had the lowest egg weight. There were no significant differences among other strains.

Feed conversion: Dietary lysine and strain significantly affected feed conversion. However, there was no interaction between strain and lysine on feed conversion (Table 2). Strain 1 had the best feed conversion whereas strain 5 had the worst. Feed conversion of strain 3 and 7 is lower than strain 4 and 6. Hens fed high lysine diets had better feed conversation than the other 2 levels.

Egg specific gravity, final body weight and mortality: Strain and dietary lysine had a significant effect on specific gravity (Table 4). Increasing dietary lysine linearly decreased egg specific gravity. This reduction in

Table 2: Effect of lysine on feed intake, egg production, egg mass, feed conversion and egg weight of seven brown egg layer strains during first cycle phase 2 (39-52 week of age)

Lysine (%)	Strain	Feed intake (g/hen per day)	Egg production (%)	Egg mass (g of egg/h per day)	Feed conversion (g of feed / g of egg)	Egg weight (g)
0.680		109.75[b]	88.49[b]	53.98[c]	2.03[a]	61.02[c]
0.747		113.06[a]	90.84[a]	57.45[b]	1.97[b]	63.40[b]
0.828		113.37[a]	92.10[a]	59.30[a]	1.91[c]	64.40[a]
	Strain 1	108.04[c]	90.89	57.07[ab]	1.90[c]	62.77[a]
	Strain 2	114.24[a]	90.44	57.04[ab]	2.01[ab]	63.04[a]
	Strain 3	111.73[bc]	89.84	57.20[ab]	1.96[b]	63.64[a]
	Strain 4	110.97[bc]	90.59	55.82[b]	1.99[ab]	61.63[b]
	Strain 5	113.45[b]	89.80	56.02[ab]	2.03[a]	62.72[a]
	Strain 6	114.48[a]	92.49	58.03[a]	1.97[ab]	62.74[a]
	Strain 7	110.97[bc]	89.29	56.58[ab]	1.96[b]	63.38[a]
0.680 x Strain	Strain 1	104.79	87.27	53.39	1.97	61.17
	Strain 2	112.33	89.66	54.85	2.05	61.17
	Strain 3	111.32	88.44	55.02	2.02	62.19
	Strain 4	109.83	89.52	53.27	2.06	59.52
	Strain 5	113.28	88.41	54.12	2.10	61.19
	Strain 6	111.36	90.89	54.92	2.03	60.44
	Strain 7	105.35	85.26	52.26	2.02	61.44
0.747 x Strain	Strain 1	109.78	91.52	57.91	1.90	63.30
	Strain 2	113.92	90.01	57.45	1.99	63.76
	Strain 3	111.75	89.49	57.04	1.96	63.73
	Strain 4	112.12	93.00	58.10	1.93	62.50
	Strain 5	111.90	88.80	54.97	2.04	62.97
	Strain 6	116.83	92.21	58.40	2.00	63.37
	Strain 7	115.15	90.88	58.27	1.98	64.15
0.828 x Strain	Strain 1	109.54	93.89	59.93	1.83	63.84
	Strain 2	116.47	91.66	58.81	1.98	64.17
	Strain 3	112.12	91.57	59.53	1.89	65.00
	Strain 4	110.95	89.26	56.07	1.98	62.86
	Strain 5	115.17	92.18	58.95	1.95	63.99
	Strain 6	115.25	94.36	60.77	1.90	64.41
	Strain 7	112.42	91.73	59.20	1.90	64.55
		1.36	1.58	1.07	0.02	0.53
Pooled SEM		--------------------	--------------------	Probability	--------------------	--------------------
Lysine		0.0017	<0.0001	<0.0001	<0.0001	<0.0001
Strain		0.0011	NS	0.0017	0.0002	<0.0001
Lysine x Strain		ns	ns	ns	ns	ns

[a-c]Means within a column and under each main effect with no common superscripts differ significantly ($p \leq 0.05$)

specific gravity can be attributed to the increased egg size caused by increased dietary lysine consumption. Sohail *et al.* (2003) also reported that increasing dietary lysine from 0.75-0.92%, significantly decreased specific gravity from 1.0848-1.0842 with Hy-line W-36 hens in phase 2. Strain 1 had the highest specific gravity whereas strain 2 had the lowest. There were no significant differences of specific gravity among strain 5, 6 and 7. A significant effect of strain on body weight was observed (Table 4). Strain 5 and 6 gained the highest body weight whereas strain 1 had the lowest. There was no significant effect of dietary lysine, strain or interaction between strain and lysine on mortality.

Strain had a significant effect on percent albumen and yolk (Table 3). Strain 4 had the highest percent yolk and strain 7 had the lowest. Strain 2 and 7 had the highest percent albumen and strain 4 and 6 had the lowest. Increasing dietary lysine significantly decreased percent shell and increased albumen and whole egg solids (Table 4). A significant strain effect was observed on whole egg solids; strain 4 had the highest whole egg solids whereas strain 3 and 7 had the lowest. As dietary lysine increased, albumen and yolk weights increased significantly.

Strain had a significant effect on shell color (Table 4). Strain 2 and 4 had the darkest egg shells whereas strain 5 had the lightest egg shells. As dietary lysine increased, both haugh unit and yolk color significantly decreased (Table 4). Increasing dietary lysine significantly decreased yolk color due to a reduction in corn use, as the level of protein increased. This result was in agreement with that of Karunajeewa (1972), who reported that increasing dietary lysine from 0.747-0.825%, significantly decreased yolk color from 6.58-6.45 with white leghorn hens.

Table 3: Effect of lysine on egg components, egg solids and albumen, yolk and shell weights of seven brown egg layer strains during first cycle phase 2 (39-52 week of age)

		Egg components (%)			Solids (%)			Albumen, Yolk, Shell weight (g)		
Lysine (%)	Strain	Yolk	Albumen	Shell	Whole egg	Albumen	Yolk	Albumen	Yolk	Shell
0.680		25.89	64.58	9.53^{a}	23.90^{b}	12.06^{b}	54.60	40.04^{b}	16.02^{b}	5.90
0.747		26.17	64.62	9.20^{b}	24.23^{a}	12.39^{a}	54.95	40.81^{b}	16.48^{ab}	5.80
0.828		25.84	64.96	9.20^{b}	24.21^{a}	12.64^{a}	54.64	42.35^{a}	16.77^{a}	5.99
	Strain 1	25.95^{cd}	64.47^{ab}	9.58	24.26^{ab}	12.30	54.52	40.13^{ab}	16.10	5.95^{ab}
	Strain 2	25.69^{cd}	65.25^{a}	9.06	24.22^{ab}	12.40	54.84	41.25^{ab}	16.21	5.72^{b}
	Strain 3	25.55^{cd}	65.00^{ab}	9.45	23.84^{b}	12.42	54.85	42.99^{a}	16.80	6.23^{a}
	Strain 4	27.05^{a}	63.68^{c}	9.27	24.50^{a}	12.53	54.95	39.66^{b}	16.84	5.77^{b}
	Strain 5	26.30^{abc}	64.58^{ab}	9.12	24.22^{ab}	12.36	54.57	40.90^{ab}	16.61	5.76^{b}
	Strain 6	26.90^{b}	63.75^{c}	9.35	24.10^{ab}	12.25	55.10	39.67^{b}	16.75	5.81^{b}
	Strain 7	24.73^{d}	65.94^{a}	9.33	23.88^{b}	12.20	54.36	42.15^{ab}	15.72	5.94^{ab}
		0.63	0.72	0.23	0.24	0.23	0.55	1.37	0.46	0.17
Pooled SEM						Probability				
Lysine		ns	ns	0.012	0.0056	0.0007	ns	0.03	0.01	ns
Strain		0.002	0.003	ns	0.0041	ns	ns	0.012	ns	0.01
LysinexStrain		ns	ns	ns	ns	ns	ns	ns	ns	ns

$^{a-c}$Means within a column and under each main effect with no common superscripts differ significantly ($p \leq 0.05$)

Table 4: Effect of lysine on specific gravity, body weight, mortality, shell color [lightness (L*), redness (a*), yellowness (b*)][1] and egg quality of 8 brown egg layer strains during first cycle phase 2 (39-52 week of age)

Lysine (%)	Strain	Egg specific gravity (Unit)	Body weight (Kg)	Mortality (%)	Egg shell color L*	a*	b*	Egg quality Haugh unit	Yolk color
0.680		1.0891^{a}	2.05	0.13	63.43	17.49	29.77	76.00^{a}	6.26^{a}
0.747		1.0878^{b}	2.00	0.15	63.27	17.53	29.89	73.54^{a}	6.15^{ab}
0.828		1.0870^{c}	2.03	0.12	62.94	17.78	29.75	70.39^{b}	6.02^{b}
	Strain 1	1.0901^{a}	1.93^{b}	0.18	62.82^{c}	17.80^{b}	29.33^{cb}	74.91^{ab}	5.98
	Strain 2	1.0861^{d}	2.05^{ab}	0.09	61.45^{d}	18.69^{a}	30.70^{a}	76.13^{a}	6.08
	Strain 3	1.0884^{b}	2.03^{ab}	0.03	63.99^{b}	17.20^{cb}	29.60^{cb}	71.68^{ab}	6.13
	Strain 4	1.0869^{cd}	1.96^{ab}	0.15	61.08^{d}	18.93^{a}	30.63^{a}	75.98^{a}	6.27
	Strain 5	1.0882^{cb}	2.09^{a}	0.18	65.09^{a}	16.49^{d}	29.45^{cb}	71.91^{ab}	6.22
	Strain 6	1.0876^{cb}	2.10^{a}	0.24	64.06^{ab}	17.22^{cb}	29.73^{cb}	70.69^{b}	6.15
	Strain 7	1.0878^{cb}	2.02^{ab}	0.06	64.05^{ab}	16.95^{cd}	29.12^{c}	71.02^{ab}	6.17
		0.01	0.07	0.11	0.89	0.60	0.50	2.50	0.16
Pooled SEM						Probability			
Lysine		<0.0001	ns	ns	ns	ns	ns	0.0001	0.009
Strain		<0.0001	<0.0001	ns	<0.0001	<0.0001	<0.0001	0.025	ns
Lysine x Strain		ns	ns	ns	ns	ns	ns	ns	ns

$^{a-c}$Means within a column and under each main effect with no common superscripts differ significantly ($p \leq 0.05$) .

[1]A higher L* value means lighter color; a higher a* value means a redder color; a higher b* value means a more yellow color

Strain 1 had the best overall performance (Table 2). Compared to brown egg laying hens of other 6 strains, strain 1 hens had the best efficiency in utilizing nutrients to produce one gram egg (Table 5). The best performance of all 7 strains was obtained with hens fed diets containing 0.828% lysine. Strain 5 (Bovans Brown classic) hens consumed 18.4 g protein, 954 mg lysine, 714 mg TSAA and 330 kcal ME per hen daily or 0.31 g protein, 16.18 mg lysine, 12.11 mg TSAA and 5.6 kcal ME per egg for the best performance (Table 5). Strain 5 required 6.5% more protein, 5.7% more TSAA and 19.9% more lysine than the values recommended by NRC (1994).

The Econometric Feeding and Management Program developed by Roland *et al.* (1998, 2000) was used to calculate profits at different dietary lysine levels and egg prices (Table 7). Current feed prices and low, medium and high price spreads were used. Maximum profits per dozen of eggs were obtained in Bovans brown classic hens (Strain 5) fed the diets containing 0.828% lysine at high price spread, 0.747% lysine at medium price spread and 0.680% lysine at low price spread. Because feed and egg prices vary, there can be no fixed dietary lysine level for optimal profits during phase 1 (39-52 week of age).

Lysine requirements to produce one gram of egg increased as dietary lysine increased (Table 6). However, energy requirement and feed conversion decreased (Table 2). This complicates effort to determine lysine requirements for optimal profits. That explains the need of an econometric program (Roland *et al.*, 1998, 2000) to determine requirements for optimal profits as feed and egg prices change.

Table 5: Nutrient requirement of seven brown egg layer strains fed diets containing 0.828% lysine during first cycle phase 2 (39-52 week of age)

	Strain 1	Strain 2	Strain 3	Strain 4	Strain 5	Strain 6	Strain 7
Nutrients required per hen daily							
Protein (g)	17.50	18.60	17.90	17.70	18.40	18.40	17.90
Lysine (mg)	907.00	964.00	928.00	919.00	954.00	954.00	931.00
TSAA (mg)	679.00	722.00	695.00	688.00	714.00	715.00	697.00
Dietary energy (kcal)	314.00	334.00	321.00	318.00	330.00	330.00	322.00
Nutrients required to produce one gram egg							
Protein (g)	0.29	0.32	0.30	0.32	0.31	0.30	0.30
Lysine (mg)	15.13	16.40	15.59	16.38	16.18	15.70	15.72
TSAA (mg)	11.33	12.28	11.68	12.27	12.11	11.76	11.77
Dietary energy (kcal)	5.24	5.68	5.40	5.67	5.6	5.44	5.44

Table 6: Nutrient requirement and nutrients required to produce one gram egg of Bovans brown classic (Strain 5) hens during first cycle phase 2 (39-52 week of age)

Lysine (%)	Protein (g)	Lysine (mg)	TSAA (mg)	Energy (kcal)
Nutrients required to produce one gram egg				
0.680	0.29	14.23	10.67	6.00
0.747	0.30	15.21	11.40	5.83
0.828	0.31	16.18	12.11	5.60
Nutrients required per hen daily				
0.680	15.6	770	578	325
0.747	16.6	836	627	321
0.828	18.4	954	714	330

Table 7: Influence of dietary lysine on profits [1] of Bovans brown classic (Strain 5) hens during first cycle phase 1 (39-52 week of age)

	Price spread		
Diet (Lysine %)	Low[2]	Medium[3]	High[4]
Returns[5] ($/dozen)			
0.828	0.302	0.429	0.751
0.747	0.306	0.431	0.750
0.680	0.306	0.429	0.738

[1]Based on a feed price of $106.44 per ton for the 0.828 lysine diet, $ 102.65 per ton for the 0.747 lysine diet and $99.28 per ton for the 0.680 lysine diet. [2]Based on an Urner Barry egg price of 31 cents/doz. for check and peewee, 40 cents/doz. for small, 57 cents/doz. for medium, 67 cents/doz. for large, 68 cents/doz. for extra large and 69 cents/doz. for jumbo eggs. [3]Based on an Urner Barry egg price of 31 cents/doz. for check and peewee, 40 cents/doz. for small, 65 cents/doz. for medium, 80 cents/doz. for large, 81 cents/doz. for extra large and 84 cents/doz. for jumbo eggs. [4]Based on an Urner Barry egg price of 31 cents/doz. for check and peewee, 40 cents/doz. for small, 75 cents/doz. for medium, 112 cents/doz. for large, 117 cents/doz. for extra large and 120 cents/doz. for jumbo eggs. [5]Returns (R) were calculated using the equation R = UBEP-NR-PC-FdC, where UBEP = Urner Berry Egg Price, NR = nest run into package product delivered, PC = production cost and FdC = feed cost as described by Roland *et al*. (1998, 2000)

Conclusion: In conclusion, the results showed that there were no interactions between lysine and strain on any parameter. Lysine had significant effects on feed consumption, egg production, egg mass, feed conversion, egg weight, egg shell components, percent yolk and whole egg solids, albumen and yolk weight, egg specific gravity, yolk color and haugh unit. There were significant strain effects on feed consumption, egg mass, feed conversion, egg weight, albumen and yolk components, whole egg solids, albumen and shell weight, egg specific gravity, body weight, shell color and haugh unit. Strain 1 had the best overall performance. All strains were laying 89.5-92.5% at 52 weeks of age. Average egg weight (39-52 week) was 63g, varying from 61.5-63.6 g between strains. Average feed intake was 112.1g/hen/day varying from 108-114 g/hen/day between strains. Average Egg weight of hens fed diets containing the highest lysine level was 3.38 g heavier than the hens fed the diets containing the lowest lysine level. Increasing dietary lysine from 0.680-0.828% significantly improved feed conversion from 2.03-1.91 g feed/g egg and increased egg mass from 54.0-59.30 g/hen/day. Average lysine intake of hens fed 0.828% level was 939 mg/hen/day varying from 907-964 mg/hen/day between strains. Because egg prices and ingredient prices often change, there can be no fixed dietary lysine level for optimal profits.

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[1]Centurion poultry Inc. Lexington, GA 30648
[2] Degussa Corporation, Allendale, NJ 07401