

1 **RUNNING TITLE: STRAIN COMPARISON**

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3 TITLE: Performance Comparison and Nutritional Requirements of Five
4 Commercial Layer Strains in Phase IV

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7 SPECIFIC SECTION: METABOLISM AND NUTRITION
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9 **SUMMARY**

10 Five commercial layer strains (Current-Bovans, Older-Bovans, Oldest-Bovans,
11 Experimental-Bovans, and Dekalb) were used to compare performance and nutrient
12 requirements when fed three protein levels (16.00, 14.85, and 13.99%). There were eight
13 replicates of 15 hens (67 wk of age) for each treatment and the trial lasted 10 weeks. The
14 results showed that there were no interactions between protein and strain on feed intake,
15 egg production, egg mass, egg weight, feed conversion, egg specific gravity, and body
16 weight of hens. Protein had significant effects on feed intake, egg mass, egg weight, egg
17 specific gravity, and body weight. There were significant strain effects on feed intake,
18 egg production, egg mass, egg weight, feed conversion and egg specific gravity. Current-
19 Bovans had the best overall performance among the five layer strains. However, Dekalb
20 had significant higher egg weight compared to Bovans. The best performance of Current-
21 Bovans and Dekalb was obtained with hens fed the diet containing 16.00% protein.
22 Current-Bovans hens required 16.5 g protein, 640 mg TSAA, 856 mg lysine, and 296
23 kcal ME per hen daily or 0.31 g protein, 12.00 mg TSAA, 16.07 mg lysine, and 5.55 kcal
24 ME per g egg for the best performance. Dekalb hens required 17.8 g protein, 691 mg
25 TSAA, 925 mg lysine, and 319 kcal ME per hen daily or 0.34 g protein, 13.04 mg TSAA,
26 17.45 mg lysine, and 6.03 kcal ME per g egg for the best performance.

27 *Key words:* Strain, Nutrient requirements, Protein, Bovans, Dekalb

DESCRIPTION OF PROBLEM

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29 The Hendrix Group, the owner of Bovans White has developed several strains of
30 Bovans White which is the second most abundant Leghorn population in US after Hy-
31 line[®] W-36. Because of changing genetics, they believe some new strains are better than
32 older strains in performance and profits. Bateman et al. [1, 2, 3] reported that there were
33 significant strain effects on egg production, egg weight, feed consumption, and egg
34 specific gravity among several strains in Phase I, II, and III. It is beneficial for
35 commercial leghorn industry to know which strain has the best performance.

36 Studies have been conducted to determine the nutritional requirement of Bovans
37 White (21-65 week). Bateman et al. [1, 2, 3] reported the nutrient requirements of Bovans
38 White hens in Phase I (21-36 week), Phase II (40-52 week), and Phase III (54-65 week).
39 As hens get older, the nutrient requirements decrease. If the nutrient content of diets fed
40 to old bird is the same as that of diets fed to young bird diets, some of nutrients may be
41 wasted and cost of production may increase. It is important for commercial Leghorn
42 industry to know the nutritional requirements of laying hens at different ages. No
43 research has been done with these strains in US in Phase IV (67-76 wks). Therefore, the
44 objective of this study was to identify which strain had the best performance among five
45 layer strains, and to determine the nutritional requirements that allow for the best
46 performance in Phase IV.

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MATERIALS AND METHODS

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The present research used four layer strains of Bovans White (Current-Bovans, Older-Bovans, Oldest-Bovans, and Experimental-Bovans), and one layer strain of Dekalb White (Dekalb). Diets containing 16.00%, 14.85% and 13.99% protein were formulated based on lysine (Table1). Each of five layer strains was fed three different diets. There were eight replicates of 15 hens (67 wk of age) for each treatment and the trial lasted 10 weeks. Replicates were equally distributed into upper and lower cage level to minimize cage level effect. Three birds were housed in 40.6 × 45.7 cm cage and five adjacent cages consisted of a group. Birds in each replicate shared a feed trough and had access to drinking cups. Feed and water were supplied *ad libitum*. This experiment was conducted in a computer regulated, environmentally controlled house with an average daily temperature of approximately 26 C. A standard lighting program (14 hour light: 10 hour dark) with a light intensity of 0.5 foot candles was used. Egg production was recorded daily, feed consumption and egg weight were recorded weekly, and egg specific gravity was recorded monthly. Egg weight and egg specific gravity were measured using all eggs produced during two consecutive days. Egg specific gravity was determined using 11 gradient saline solutions varying in specific gravity from 1.060 to 1.100 incremented by 0.005-unit increments [4]. Mortality was determined daily and the feed consumption was adjusted accordingly. Body weight was obtained by weighing 3 hens per group at the end of the experiment. Egg mass and feed conversion (g feed/g egg) were calculated from egg production, egg weight and feed consumption.

69 Data was analyzed using general liner model procedure (PROC GLM) in SAS
70 [5]. A 5×3 factorial design was used to analyze data of performance of five layer strains
71 fed 3 diets. The statistical model was:

$$72 \quad Y_{ijk} = \mu + P_i + S_j + PS_{ij} + e_{ijk}$$

73 where Y_{ijk} is the k -th response for the treatment combination $P_i S_j$, μ is the overall
74 mean, P_i is protein effect, S_j is strain effect, PS_{ij} is the interaction of protein and strain,
75 e_{ijk} is the random error. If differences in treatment means were detected by ANOVA,
76 Duncan's Multiple Range Test was applied to separate means. Statements of statistical
77 significance are based on a probability of ($P \leq 0.05$).

RESULTS AND DISCUSSION

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79 *Feed consumption*

80 There was no significant interaction between strain and protein on feed
81 consumption of five layer strains (Table 2). There was a significant strain effect on feed
82 consumption. Feed consumption of Current-Bovans was significantly lower than that of
83 Older-Bovans, Oldest-Bovans, and Dekalb, but was similar to that of Experimental-
84 Bovans. There were no significant differences in feed consumption among Older-Bovans,
85 Oldest-Bovans, and Dekalb. Protein had a significant effect on feed consumption. As
86 protein level increased from 13.99% to 16.00%, feed consumption linearly increased
87 from 102.86 to 105.55 g/h/d, resulting in a net increase of 2.69 g/h/d. This result was in
88 agreement with Holcombe et al. [6] who reported that hens fed diets deficient in protein
89 could decrease feed consumption.

90 *Egg production*

91 There was a significant strain effect on egg production (Table 2). Current-Bovans
92 had egg production at 81.06%, which was significantly higher than other three Bovans
93 strains and Dekalb. This result was consistent with the previous reports that strain
94 significantly affected egg production [1, 2, 3]. Protein did not significantly affect egg
95 production. There was no significant interaction between strain and protein on egg
96 production.

97 *Egg mass*

98 A significant strain effect on egg mass was observed (Table 2). Current-Bovans
99 had the highest egg mass among five strains. Protein had a significant effect on egg mass.

100 As protein level increased from 13.99% to 16.00%, egg mass linearly increased from
101 47.60 to 50.40 g, resulting in a 5.88% increase in egg mass. There was no significant
102 interaction between strain and protein on egg mass.

103 ***Egg weight***

104 There was a significant strain effect on egg weight (Table 2). Egg weight of
105 Dekalb was significantly higher than that of four Bovans strains. There were no
106 significant differences in egg weight among four Bovans Strains. Protein had a
107 significant effect on average egg weight. Protein linearly increased egg weight from
108 62.35 to 64.47 g, resulting in a net increase of 2.12 g. There was no significant interaction
109 between strain and protein on egg weight. This result was in agreement with the previous
110 reports that egg weight was significantly affected by strain and protein [1, 2, 3].

111 ***Feed conversion***

112 A significant strain effect on feed conversion was observed (Table 2). Feed
113 conversion of Current-Bovans was significantly lower than that of other four strains.
114 Oldest-Bovans had the highest feed conversion among five strains. Feed conversion was
115 not significantly affected by protein. There was no significant interaction between strain
116 and protein on feed conversion.

117 ***Egg specific gravity, final body weight, and mortality***

118 There was no significant interaction between strain and protein on egg specific
119 gravity (Table 2). Strain had a significant effect on egg specific gravity. Dekalb had the
120 highest egg specific gravity, and Experimental-Bovans had the lowest egg specific
121 gravity. Protein can significantly affect egg specific gravity. Hen fed the diet containing

122 13.99% protein had significantly higher egg specific gravity than hens fed the diets
123 containing 14.85% and 16.00% protein. The improvement of egg specific gravity in hens
124 fed the diet containing 13.99% protein might be due to egg weight of hen fed the diet
125 containing 13.99% protein being significantly lower than that of hens fed the diets
126 containing 14.85% and 16.00% protein. Protein had a significant linear effect on final
127 body weight of hens. As protein level increased from 13.99% to 16.00%, final body
128 weight of hens linearly increased from 1.84 to 1.96 kg, resulting in a 6.5% increase in
129 body weight. There was no significant interaction between strain and protein on body
130 weight. During the 10 weeks trial, total mortality was 1.37%.

131 Both strain and protein had significant effects on performance of laying hens.
132 Current-Bovans had the best performance among five layer strains (Table 2). However,
133 Dekalb had significant higher egg weight compared to Bovans. The best performance of
134 Current-Bovans, Oldest-Bovans, Experimental-Bovans, and Dekalb was obtained with
135 hens fed the diet containing 16.00% protein, while the best performance of Older-Bovans
136 was obtained with hens fed the diet containing 14.85% protein. Current-Bovans hens
137 required 16.5 g protein, 640 mg TSAA, 856 mg lysine, and 296 kcal ME per hen daily or
138 0.31 g protein, 12.00 mg TSAA, 16.07 mg lysine, and 5.55 kcal ME per g egg for the best
139 performance (Table 3). Current-Bovans in Phase IV required 10% more protein, 10%
140 more TSAA, and 24% more lysine than the values recommended by NRC [7]. Compared
141 to hens of the other three Bovans strains and Dekalb, Current-Bovans hens had the best
142 efficiency in utilizing nutrients to produce one gram egg (Table 3). Bateman et al. [1, 2,
143 3] reported that Bovans White hens required 19.3 g protein, 753 mg TSAA, and 1052 mg

144 lysine per hen daily in Phase I, required 18.6 g protein, 804 mg TSAA, and 987 mg lysine
145 per hen daily in Phase II, and required 18.2 g protein, 696 mg TSAA, and 932 mg lysine
146 per hen daily in Phase III. The nutrient requirements of Bovans White hens in Phase IV
147 were less than those of hens in Phase I, Phase II, and Phase III [1, 2, 3].

148 Dekalb hens required 17.8 g protein, 691 mg TSAA, 925 mg lysine, and 319 kcal
149 ME per hen daily or 0.34 g protein, 13.04 mg TSAA, 17.45 mg lysine, and 6.03 kcal ME
150 per g egg for the best performance (Table 3). Dekalb in Phase IV required 19% more
151 protein, 19% more TSAA, and 34% more lysine than the values recommended by NRC
152 [7]. Bateman et al. [1, 2, 3] reported that Dekalb White hens required 20.0 g protein, 782
153 mg TSAA, and 1093 mg lysine per hen daily in Phase I, required 18.2 g protein, 788 mg
154 TSAA, and 966 mg lysine per hen daily in Phase II, required 17.9 g protein, 685 mg
155 TSAA, and 916 mg lysine per hen daily in Phase III. The nutrient requirements of Dekalb
156 White hens in Phase IV were less than those in Phase I, Phase II, but were similar to
157 those in Phase III [1, 2, 3].

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CONCLUSIONS AND APPLICATIONS

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1. Protein had significant effects on feed intake, egg mass, egg weight, egg specific gravity, and body weight. There were significant strain effects on feed intake, egg production, egg mass, egg weight, feed conversion and egg specific gravity.

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2. Current-Bovans had the best performance among five layer strains. However, Dekalb had significant higher egg weight compared to Bovans.

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3. The best performance of Current-Bovans and Dekalb was obtained with hens fed the diet containing 16.00% protein.

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4. Current-Bovans hens required 16.5 g protein, 640 mg TSAA, 856 mg lysine, and 296 kcal ME per hen daily or 0.31 g protein, 12.00 mg TSAA, 16.07 mg lysine, and 5.55 kcal ME per g egg for the best performance.

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5. Dekalb hens required 17.8 g protein, 691 mg TSAA, 925 mg lysine, and 319 kcal ME per hen daily or 0.34 g protein, 13.04 mg TSAA, 17.45 mg lysine, and 6.03 kcal ME per g egg for the best performance.

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194 TABLE 1. Ingredients and nutrient composition of experimental diets

Ingredients (%)	Diet 1	Diet 2	Diet 3
Corn	64.39	67.95	70.62
Soybean meal (48% protein)	22.52	19.56	17.35
CaCO ₃	7.24	7.25	7.26
Hardshell ¹	2.00	2.00	2.00
Dicalcium phosphate	1.29	1.31	1.32
Poultry oil	1.61	1.01	0.56
NaCl	0.39	0.39	0.39
Vitamin Premix ²	0.25	0.25	0.25
Mineral premix ³	0.25	0.25	0.25
DL-Methionine	0.07	0.03	0.01
Calculated analysis (%)			
CP (%)	16.00	14.85	13.99
ME (kcal/kg)	2865.64	2865.64	2865.64
Ca (%)	4.00	4.00	4.00
AP (%)	0.34	0.34	0.34
Methionine (%)	0.33	0.29	0.26
Metionine+Cystine (%)	0.62	0.56	0.52
Lysine (%)	0.83	0.75	0.69

195 ¹Hardshell = large particle (passing US mesh #4 and retained by US mesh #6) CaCO₃
 196 supplied by Franklin Industrial Minerals, Lowell, Florida.

197 ²Provided per kilogram of diet: vitamin A, 8,000 IU; cholecalciferol, 2,200 ICU; vitamin
 198 E, 8 IU; vitamin B₁₂, 0.02 mg; riboflavin, 5.5 mg; D-calcium pantothenic acid, 13 mg;
 199 niacin, 36 mg; choline, 500 mg; folic acid, 0.5 mg; vitamin B₁ (thiamin mononitrate), 1
 200 mg; pyridoxine, 2.2 mg; biotin, 0.05 mg; vitamin K (menadione sodium bisulfate
 201 complex), 2 mg.

202 ³Provided per kilogram of diet: manganese, 65 mg; iodine, 1 mg; ferrous carbonate, 55
 203 mg; copper oxide, 6 mg; zinc oxide, 55 mg; sodium selenium, 0.3 mg.

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TABLE 2. Effect of strain and protein on performance of five strains (67-76 wk of age)

Factor		Feed intake (g/hen/day)	Egg production (%)	Egg mass (g/hen/day)	Egg weight (g)	Feed conversion (g feed/g egg)	Egg specific gravity (unit)	Body weight (kg)
Protein	16.00%	105.55 ^a	78.18	50.40 ^a	64.47 ^a	2.10	1.0749 ^b	1.96 ^a
	14.85%	103.59 ^{ab}	75.66	48.03 ^b	63.56 ^b	2.17	1.0748 ^b	1.90 ^b
	13.99%	102.86 ^b	76.40	47.60 ^b	62.35 ^c	2.17	1.0756 ^a	1.84 ^b
Strain	Current-Bovans	101.59 ^b	81.06 ^a	51.03 ^a	62.96 ^b	2.00 ^d	1.0756 ^b	1.83
	Older-Bovans	105.29 ^a	77.95 ^b	48.94 ^b	62.82 ^b	2.16 ^{bc}	1.0757 ^b	1.93
	Oldest-Bovans	105.45 ^a	74.65 ^c	46.92 ^c	62.86 ^b	2.26 ^a	1.0743 ^c	1.91
	Exp-Bovans	101.42 ^b	76.17 ^{bc}	48.07 ^{bc}	63.12 ^b	2.12 ^c	1.0732 ^d	1.89
	Dekalb	106.25 ^a	73.90 ^c	48.43 ^{bc}	65.54 ^a	2.21 ^{ab}	1.0765 ^a	1.93
16.00% Protein	Current-Bovans	103.16	82.93	53.27	64.26	1.94	1.0751	1.89
	Older-Bovans	104.97	76.60	48.86	63.78	2.15	1.0762	1.93
	Oldest-Bovans	105.92	74.23	47.23	63.63	2.25	1.0739	1.98
	Exp-Bovans	102.26	77.90	49.69	63.83	2.06	1.0731	2.00
	Dekalb	111.44	79.26	52.95	66.87	2.11	1.0760	1.99
14.85% Protein	Current-Bovans	102.88	79.79	50.17	62.91	2.06	1.0755	1.85
	Older-Bovans	106.19	78.98	49.88	63.20	2.14	1.0751	1.94
	Oldest-Bovans	104.10	74.74	46.87	62.69	2.23	1.0740	1.91
	Exp-Bovans	101.75	74.54	47.05	63.16	2.17	1.0726	1.81
	Dekalb	103.00	70.22	46.19	65.84	2.24	1.0766	1.97
13.99% Protein	Current-Bovans	98.74	80.46	49.65	61.72	2.00	1.0763	1.75
	Older-Bovans	104.71	78.26	48.09	61.47	2.18	1.0759	1.92
	Oldest-Bovans	106.31	74.97	46.67	62.25	2.29	1.0749	1.84
	Exp-Bovans	100.23	76.07	47.46	62.37	2.12	1.0739	1.86
	Dekalb	104.30	72.22	46.14	63.93	2.28	1.0769	1.83
	SEM	1.11	1.86	1.17	0.49	0.04	0.0004	0.10
	ANOVA	-----Probability-----						
	Protein	0.0273	0.0931	0.0005	0.0001	0.0811	0.0120	0.0007
	Strain	0.0004	0.0001	0.0010	0.0001	0.0001	0.0001	0.0730
	Protein × Strain	0.0639	0.1556	0.0603	0.7291	0.6707	0.6266	0.3456

TABLE 3. Nutrient requirements of five layer strains

	Nutrients required per hen daily				Nutrients required to produce one gram egg			
	Protein (g)	TSAA (mg)	Lysine (mg)	Dietary energy (Kcal)	Protein (g)	TSAA (mg)	Lysine (mg)	Dietary energy (kcal)
Current-Bovans	16.5	640	856	296	0.31	12.00	16.07	5.55
Older-Bovans	15.8	595	796	304	0.32	12.17	16.30	6.23
Oldest-Bovans	17.0	657	879	304	0.36	13.90	18.61	6.43
Exp-Bovans	16.4	634	849	293	0.33	12.75	17.07	5.89
Dekalb	17.8	691	925	319	0.34	13.04	17.45	6.03