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EFFECT OF AN ANTIOXIDANT (ETHOXYQUIN) ON THE PERFORMANCE OF LAYING HENS

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Antioxidants have been used for many years by the feed industry to prevent oxidative rancidity in mixed rations, especially those containing polyunsaturated fats. When such rancidity occurs, there may be a concurrent destruction of the fat-soluble vitamins (A, D, and E). Lysine, an amino acid, may also be adversely affected by the breakdown products of rancidity.

More recently, biologists studying the aging process in animals have accumulated some evidence that antioxidants in the diet may promote increased longevity. For example, mice fed a ration containing 0.5 to 1.0% antioxidants showed life-span increases of 30 to 45%.

One theory of aging is that it is the result, in part, of "free radicals" in the animal body, becoming involved in a series of oxidative reactions leading to the cross-linking of various biomolecules. The rate at which aging progresses is then dependent on the incidence of free radical promoters and amount of available oxidants present in the tissues to stimulate cross-linkage and increase chain-length of the new compounds generated. Thus, antioxidants may be effective in retarding the aging process in that they have been shown to scavenge free radicals, inhibit peroxide formation, and slow down oxidation of unsaturated lipids.

The purpose of the study undertaken here was to determine whether inclusion of an antioxidant in the diet of laying hens would extend their productive life and improve performance as measured by rate of lay, feed conversion efficiency, mortality, and egg quality. If these advantages were realized, there would be additional evidence that antioxidants, indeed, may be involved in the aging process. The antioxidant used in this test was a feed-grade ethoxyquin (6-ethoxy-1, 2-dihydro-2, 2,4-trimethylquinoline).

EXPERIMENTAL PROCEDURE

Location: Moreno Ranch poultry research facility of the University of California, Riverside.

Stock: A commercial strain of White Leghorn hens, 90 weeks of age, which had been force molted 8 weeks prior to the start of the experiment.

Duration of Experiment: Eight 4-week periods - Feb. 1 to Sept. 13, 1977.

Housing: California open-type house with curtain side walls, roof sprinklers, and hot weather foggers. All cages 12" wide by 18" deep, back to back, 3 birds per cage.

Feeding: Hand feeding *ad libitum*, front feed trough.

Watering: Hart cups.

Treatments: A. Control ration (no added ethoxyquin), B. Control ration plus 4 ounces ethoxyquin per ton (4E), and C. Control ration plus 8 ounces ethoxyquin per ton (8E).

Experimental Design: Completely randomized, 5 replicates of 15 hens each per treatment (5 x 15 x 3 = 225 hens total).

Ration Forumla:

Ground corn	40.45%
Ground milo	23.74
Meat and bone meal	7.50
Limestone	7.50
Soybean meal (48% protein)	5.00
Cottonseed meal (48% protein)	5.00
Wheat, mill run	5.00
Dehydrated alfalfa meal	2.50
Fish solubles	1.50
Fish meal	1.00
Fat	.50
Vitamin-mineral premix	.25
Methionine hydroxy analogue	.06

Calculated Ration Analysis:

Energy (ME), kcal/lb	1267
Protein, %	16.7
Fat, %	4.0
Fiber, %	3.4
Ash, %	11.5
Calcium, %	3.8
Phosphorus (available), %	.53
Methionine, %	.34
Methionine and cystine, %	.58
Lysine, %	.78

Measurements: Daily egg production, feed consumption, and mortality; sample egg weights at 4-week intervals; sample body weights at beginning and end of test; candled egg breakage and shell roughness score at 4-week intervals; sample Haugh unit values and shell thickness at end of 1st, 3rd, 5th, and 7th periods. Duncan's Multiple Range Test was used to determine significant differences among treatments.

RESULTS AND DISCUSSION

Performance by 4-week periods is presented in Tables 1 and 2, and overall results for the entire 32-week test are summarized in Table 3.

Significant differences among treatments were observed in just two areas--feed consumption and mortality. Feed intake was slightly lower for the 4E group, but this may have been related to a slightly lower rate of egg production. Variation in feed consumption also significantly affected, as one would expect, the intake of energy, protein, individual amino acids, and minerals (see Table 3).

Total mortality for the 32-week test was significantly less for both ethoxyquin groups compared to hens on the control ration without added ethoxyquin. Each of the five 15-bird replicates in the control group lost from one to three hens, whereas none of the 4E replicates experienced any mortality. This difference was highly significant ($P < 0.01$). If such differences could be duplicated in larger numbers of birds under commercial conditions, without affecting other performance traits, they would have a significant economic effect through enhanced hen-housed production.

Rates of egg production for the two ethoxyquin treatment groups were numerically below those of the controls during six of the eight 4-week periods. During the sixth period the difference extended to 13 percentage points for the 4E group and was highly significant ($P < 0.01$). Feed intake, for some unidentified reason, was also significantly lower ($P < 0.05$) for this period, and this could account for the lower production rate. However, in the overall analysis, there were no significant differences among any of the 3 treatments in hen-day or hen-housed production or in efficiency of feed conversion. Consequently, there is no basis for concluding that the addition of ethoxyquin to rations at the levels used in this experiment would have any adverse effect on egg production.

Egg size and egg quality were unaffected by treatment. Numerically, there was less shell damage in the ethoxyquin groups as measured by percentage of cracked eggs, but the differences were nonsignificant. Shell thickness, shell roughness score, and albumen quality were essentially identical for all treatments.

An economic analysis of the performance data using Duncan's Multiple Range Test failed to demonstrate any real differences in costs or returns due to treatment

(continued on page 6)

Table 1. Egg production, feed intake and conversion, protein and energy intake, and mortality by 4-week periods

4-week period	Treatment	Egg production		Feed		Protein intake	Energy intake	Hen-housed mortality
		Hen-day	Hen-housed	Intake	Conversion			
		(%)	(eggs)	(lb/HD[1])	(lb/doz)	(g/HD)	(ME Cal/HD)	(%)
1	Control	63.6	17.6	.258	4.9	19.5	326	1.4
	4E[2]	66.2	18.5	.257	4.7	19.5	326	0.0
	8E[3]	69.5	19.4	.262	4.6	19.9	332	0.0
2	Control	73.2	20.1	.269	4.4	20.3	340	1.5
	4E	68.9	19.3	.260	4.6	19.7	329	0.0
	8E	71.4	19.9	.259	4.4	19.6	328	1.5
3	Control	69.3	18.6	.251	4.4	19.0	317	2.7
	4E	69.3	19.4	.247	4.3	18.7	313	0.0
	8E	71.3	19.6	.257	4.3	19.5	326	0.0
4	Control	72.8	19.2	$.274^{A}_{B}$	4.5	20.7^{A}_{B}	346^{A}_{B}	0.0
	4E	69.4	19.4	$.241^{A}$	4.2	18.3^{A}	305^{A}	0.0
	8E	71.4	19.7	$.272^{A}$	4.6	20.6^{A}	346^{A}	0.0
5	Control	73.2	19.3	.252	4.1	19.1	319	0.0
	4E	65.9	18.4	.251	4.6	19.0	317	0.0
	8E	70.2	19.4	.246	4.2	18.6	312	0.0
6	Control	70.6^{A}_{B}	18.6^{a}_{b}	$.252^{a}_{b}$	4.3	19.1^{a}_{b}	319^{a}_{b}	0.0
	4E	57.9^{AB}	16.2^{ab}	$.227^{b}$	4.8	17.2^{b}	287^{b}	0.0
	8E	65.7^{AB}	18.1^{ab}	$.249^{a}$	4.5	18.8^{a}	315^{a}	0.0
7	Control	64.0	16.9	.198	3.7	15.0	251	0.0
	4E	61.2	17.1	.204	4.0	15.4	258	0.0
	8E	59.5	16.4	.189	3.8	14.3	239	0.0
8	Control	60.0	15.5	.197	4.0	14.9	250	2.9
	4E	56.3	15.8	.199	4.3	15.1	252	0.0
	8E	58.7	16.0	.197	4.2	15.0	250	1.3

1/ Hen-day.
2/ Control ration plus 4 oz. ethoxyquin/ton.
3/ Control ration plus 8 oz. ethoxyquin/ton.

a, b, A, B
Means within columns and within periods having different superscripts are significantly different; lower case $P < 0.05$; upper case $P < 0.01$.

Table 2. Egg weight, shell quality, and albumen quality by 4-week periods[1/]

4-week period	Treatment	Avg. egg weight	Cracked shells	Shell thickness	Shell score[2/]	Albumen height	Haugh units
		(g)	(%)	(in. x 10^{-3})		(mm)	
1	Control	64.7	1.8	15.2	.12	7.3	83.8
	4E[3/]	64.3	0.0	15.2	.18	7.2	83.4
	8E[4/]	64.7	0.0	15.2	.22	7.4	84.6
2	Control	65.7	2.9		.35		
	4E	65.6	2.2		.53		
	8E	65.3	0.0		.40		
3	Control	65.4	3.3	14.5	.31	6.9	81.8
	4E	65.0	0.0	14.6	.39	6.5	79.4
	8E	65.3	0.0	14.5	.35	6.7	80.6
4	Control	64.7	0.0		.32		
	4E	64.8	0.0		.39		
	8E	65.3	0.0		.32		
5	Control	64.7	5.8	13.8	.53	6.6	79.0
	4E	64.7	4.3	13.7	.46	6.9	81.8
	8E	65.7	7.7	14.1	.41	6.5	78.6
6	Control	63.6	3.0		.73		
	4E	63.0	6.7		.63		
	8E	64.5	3.1		.67		
7	Control	61.8	4.5	13.5	.85	6.2	77.2
	4E	62.6	0.0	13.5	.90	6.1	75.8
	8E	63.5	0.0	13.3	.82	6.1	76.0
8	Control	62.3	6.3		.81		
	4E	62.9	8.3		.90		
	8E	64.0	2.9		.69		

1/ No significant differences among treatments ($P > 0.05$) using Duncan's Multiple Range Test.
2/ Shell roughness score: 0 = smooth; 3 = very rough.
3/ Control ration plus 4 oz. ethoxyquin/ton.
4/ Control ration plus 8 oz. ethoxyquin/ton.

Table 3. Overall results for periods 1 through 8 (32 weeks)

Trait	Control	4E[1/]	8E[2/]
Hen day egg production, %	68.3	64.4	67.2
Eggs per hen housed	146	144	149
Total egg wt/hen-housed, kg	9.37	9.25	9.64
Feed per hen-housed, kg	23.7	24.0	24.3
Feed per hen-day, g	111^{a}	107^{b}	110^{ab}
Protein per hen-day, g	18.5^{a}	17.9^{b}	18.3^{ab}
Methionine per hen-day, mg	376^{a}	363^{b}	372^{ab}
Methionine + cystine per hen-day, mg	642^{a}	620^{b}	635^{ab}
Lysine per hen-day, mg	863^{a}	834^{b}	854^{ab}
Calcium per hen-day, g	3.87^{a}	3.74^{b}	3.83^{ab}
Available phosphorus per hen-day, g	.59^{a}	.57^{b}	.58^{ab}
Calories (ME) per hen-day	309^{a}	299^{b}	306^{ab}
Feed per dozen eggs, kg	1.95	2.00	1.96
Feed per 24-oz. dozen, lb	3.79	3.89	3.78
Feed:Egg ratio	2.53	2.59	2.52
Candled cracked eggs, %	3.53	3.05	1.70
Shell thickness (microns)	361	363	363
Shell score [3/]	.50	.55	.49
Albumen height (mm)	6.8	6.7	6.7
Haugh units	80.5	80.1	80.0
Average egg weight, g	64.2	64.2	64.8
Large eggs and above, %	94.8	95.2	95.8
Body weight gain, %	7.7	4.8	4.1
Mortality (hen-housed), %	8.5^{aA}	0.0^{bB}	2.9^{bAB}

1/ Control ration plus 4 oz. ethoxyquin/ton.

2/ Control ration plus 8 oz. ethoxyquin/ton.

3/ Shell roughness score: 0 = smooth; 3 = very rough.

a, b, A, B
Means within rows followed by different superscripts are statistically different; lower case $P < 0.05$; upper case $P < 0.01$.

Table 4. Economic analysis, periods 1 through 8 (32 weeks) 1/

Trait	Control	4E 2/	8E 3/
	($)	($)	($)
Feed cost per hen housed 4/	3.39	3.44	3.49
Feed cost per dozen eggs	.279	.287	.283
Average egg value per dozen 5/	.447	.447	.448
Egg income minus feed cost/hen housed	2.05	1.93	2.05

1/ No significant differences among treatments (P > 0.05) using Duncan's Multiple Range Test.
2/ Control ration plus 4 oz. ethoxyquin/ton.
3/ Control ration plus 8 oz. ethoxyquin/ton.
4/ Ration cost per 100 lbs; Control-$6.50; 4E-$6.52; 8E-$6.54.
5/ Egg price per dozen: Large-45¢; Medium-40¢; Small-25¢.

(Table 4). If the 4E group had not experienced lower egg production, it would have had a substantial economic advantage because of the lower mortality rate.

CONCLUSIONS

The results of this experiment offer little evidence that adding an antioxidant such as ethoxyquin to the ration of laying hens at levels of 4 to 8 ounces per ton is effective in improving their performance or extending their productive life. Aging in birds is characterized by decreasing rates of production and loss of quality in the shell and albumen. No retardation in these changes was noted on the addition of ethoxyquin.

The reduction in mortality, however, is of interest because of its economic impact, provided general performance is not also reduced. A larger scale experiment would seem justified in order to more precisely measure mortality differences.

The hens in this experiment were 90 weeks of age before being fed rations with added ethoxyquin. Different results may have been obtained if they had been placed on such diets at an earlier age, before the onset of irreversible aging processes.

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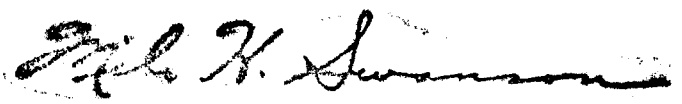

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