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Selenium and Development of Exudative Diathesis in Chicks.* (23815)

B. L. REID, M. M. RAHMAN, B. G. CREECH AND J. R. COUCH

*Departments of Poultry Science and Biochemistry and Nutrition, Texas Agric. Exp. Station,
College Station*

A number of workers have reported the development of exudative diathesis as a symptom of Vit. E deficiency using the diet of Scott *et al.*(1). It was recently reported that organic complex of selenium was the factor 3 of dried brewers yeast necessary for prevention of liver necrosis in rats fed a similar Vit. E-free Torula yeast diet(2); and selenium was also found to be active in this regard. Schwarz *et al.*(2) have shown that selenium or factor 3 concentrates would prevent the gross symptoms of exudative diathesis in chicks fed Torula yeast. Patterson *et al.*(3) have identified selenium as the active component of casein and defatted pork kidney in preventing development of exudative diathesis in chicks. Previous work has shown that exudative diathesis of the chick or poult resulted in marked diminution of hemoglobin level, total serum protein (albumin level), and total red cell counts. These conditions could be prevented by adding Vit. E or substituting 10% dried brewers yeast in the Torula yeast diet(4,5).

In view of these results it seemed desirable

to determine the effect of selenium on occurrence of the blood changes associated with exudative diathesis.

Methods. In the first study, 5 groups of 20 White Rock chicks were placed on the Torula yeast diets supplemented as shown in Table I. The basal diet used in this study is the same as that of Creech *et al.*(5). Selenium was supplied as sodium selenate at levels of 1 and 10 ppm. At the end of 3 weeks, when gross symptoms of exudative diathesis had appeared in birds fed the basal diet, a representative sample (5 birds per group) was selected for the determination of total serum protein, albumin:globulin ratios, red cell counts, hemoglobin, and packed cell volume as previously described(5). The second study in this series employed 20 New Hampshire chicks per group with the basal diet supplemented as shown in Table III. Selenium was supplied as sodium selenate (1, 0.5, 0.1 ppm), as the selenite (1 ppm), and as free selenium (0.5 ppm). At 3 weeks of age a representative sample of birds from each group was removed for the blood analyses previously listed. The birds in both experiments were housed in electrically heated batteries with raised wire floors; feed and water were supplied *ad libitum*. Body weights were determined at weekly intervals throughout the study, and daily observations were made for the appearance of symptoms of exudative diathesis.

Results. The addition of selenium as the selenate either at the level of 1 ppm or 10 ppm completely prevented development of gross symptoms of exudative diathesis up to

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4 weeks of age, as previously reported by Schwarz *et al.* (2). Symptoms of exudative diathesis were likewise prevented by addition of 20 mg of *d*-alpha tocopheryl acetate per lb or substitution of 10% dried brewers yeast in the Torula yeast basal diet (Table I). The first symptoms of exudative diathesis appeared in the basal group on the 17th day and increased to an incidence of 65% by the 21st day. Birds fed 1 ppm selenium or 10 ppm selenium appeared to be depressed in growth when compared to the birds fed 20 mg of Vit. E/lb or 10% dried brewers yeast (Table I).

The serum albumin:globulin (A/G) ratios, as determined by electrophoresis at 21 days, were markedly reduced in birds receiving the unsupplemented Torula yeast basal diet (Table I). The A/G ratio of this group was 0.16 whereas the birds receiving 20 mg of *d*-alpha tocopheryl acetate per lb of feed exhibited an A/G ratio of 0.73, and the dried brewers yeast fed group had a ratio of 0.80. A partial improvement in the A/G ratio was observed with the addition of selenium to the basal diet. The 1 ppm level (selenate) resulted in an A/G ratio of 0.5, while the 10 ppm level resulted in a ratio of only 0.32. The latter may have been due to toxicity of the higher level of selenium.

A marked reduction in the number of red blood cells was noted in the unsupplemented group (1.8 million). This level was elevated to 2.12 million in the Vit. E supplemented group and to 2.32 million in the dried brewers yeast fed group (Table II). The 1 ppm level of selenium resulted in a cell count of 2.05 million, which is approximately normal under

TABLE II. Effect of Selenium on Blood Picture of Torula Yeast Fed Chicks at 21 Days.

Supplement to basal diet	R.B.C. in millions	Hemo-globin, g %	Mean cell vol, mm ³ (10 ⁻⁷)	Total serum protein
None	1.80	5.11	156	3.18
20 mg vit. E/lb	2.12	6.69	142	3.77
10% dried brewers yeast	2.32	7.11	143	4.47
1 ppm selenium (Selenate)	2.05	5.35	134	3.47
10 ppm <i>Idem</i>	1.92	5.33	141	3.04

the conditions of this study, and the 10 ppm level of selenium produced a 1.92 million cell count. Hemoglobin levels were markedly reduced in the basal diet (5.11) and returned to normal with the feeding of Vit. E or dried brewers yeast. Very little improvement was observed after addition of selenium to the basal diet. The mean cell volumes were affected only to a slight extent by any of the supplements, or the deficiency of Vit. E in this study. The total serum protein level was increased from 3.18 in the unsupplemented group to 3.77 in the group fed 20 mg of Vit. E per lb of diet, and to 4.47 in the group fed 10% dried brewers yeast. Addition of 1 ppm of selenium resulted in a total protein level, as determined chemically, of 3.47 which represents a slight increase over that obtained with the unsupplemented diet. The 10 ppm level of selenium failed to produce an increase of total serum protein level.

In the second study (Table III), it was found that as little as 0.1 ppm of selenium, added as sodium selenate, resulted in complete protection from symptoms of exudative diathesis to 4 weeks of age. One ppm of selenium as selenite and dried brewers yeast at a 10% level exerted a protective effect with regard to exudative diathesis. However, when the ash of dried brewers yeast was fed at the level equivalent to 10%, a 95% incidence of exudative diathesis was noted by the end of the 4th week. The brewers yeast was burned over an open flame until charring had been initiated and then placed in a muffled furnace at 400° to 500°C for 12 hours. Under these conditions it might be expected that selenium would be lost to a significant extent from the dried brewers yeast ash. The addition of 0.5

TABLE I. Effect of Selenium on Growth and Incidence of Exudative Diathesis in Chicks Fed a Torula Yeast Diet.

Supplement to basal diet	Avg wt		% birds showing symptoms	A/G ratio, 21 days
	21 days	28 days		
None	240	260 (3 birds)	100*	.16
20 mg vit. E/lb	220	276	0	.73
10% dried brewers yeast	240	309	0	.80
1 ppm selenium (Selenate)	213	255	0	.50
10 ppm <i>Idem</i>	187	223	0	.32

* First developed on 17th day; 65% incidence by 21st day.

TABLE III. Effect of Selenium on Growth and Incidence of Exudative Diathesis in Chicks Fed a Torula Yeast Diet.

Supplement to basal diet	Avg wt		% exudative diathesis		Appearance of symptoms, days	% mortality at 28 days
	3 wk	4 wk	3 wk	4 wk		
None	190	247 (7 birds)	76	95	17	65*
20 mg <i>d</i> -alpha tocopheryl acetate	220	312	0	0		
1 ppm Se (sodium selenate)	166	204	0	0		5†
.5 ppm <i>idem</i>	200	293	0	0		
.1 ppm "	237	337	0	0		
1 ppm Se (sodium selenite)	212	297	0	0		
10% dried brewers yeast	224	323	0	0		
Dried brewers yeast ash (equivalent to 10% dried brewers yeast)	192	225 (2 ")	35	95	19	90
.5 ppm Se (free selenium)	182	167 (4 ")	35	80	19	80

* Two birds died at 8th day without symptoms.

† One out of 20 birds died on 21st day without symptoms.

ppm selenium as the free metal failed to produce complete protection against exudative diathesis since there was an 80% incidence of this condition at the end of the 4th week. The growth rate of the birds to 4 weeks of age appeared to be increased by feeding 0.1 ppm selenium as selenate. The average 4-week weight of these birds was 337 g as compared to 312 g for the Vit. E supplemented group. Only 7 birds remained in the unsupplemented group at the end of the 4th week with an average weight of 247 g. In this study, 1 ppm selenium again seemed to produce a depression in growth rate.

Red blood cell counts again were reduced in the absence of Vit. E. to 1.93 million, whereas the Vit. E supplemented group exhibited a count of 2.52 million, (Table IV). The 3 levels of selenium supplied as the selenate (1 ppm, 0.5 ppm and 0.1 ppm) produced

counts of 2.12, 2.37, and 2.47 million, respectively. Addition of 1 ppm selenium as selenite produced a count of 2.26 million. Dried brewers yeast again resulted in an elevation of the counts in the birds fed this diet. The ash of dried brewers yeast failed to produce an appreciable effect on the counts. A 0.5 ppm level of free selenium seemed to exert some influence with regard to counts.

Hemoglobin levels were elevated with addition of Vit. E, selenium, as a selenate at a level as low as 0.1 ppm, as the selenite at a level of 1 ppm, and 10% dried brewers yeast. No significant improvement was obtained with the dried brewers yeast ash, under the conditions of this study, however, 0.5 ppm of free selenium did seem to exert some influence with regard to hemoglobin level. It should be noted that no evidence has been obtained that selenium, Vit. E, or dried brewers

TABLE IV. Effect of Selenium on R.B.C., Hemoglobin, Mean Cell Volume and Total Serum Protein in Chicks on Torula Yeast Diet.

Supplement to basal diet	R.B.C. in millions	Hemoglobin, g %	Mean cell vol, mm ³ (10 ⁻⁷)	Total serum protein (chemical)	A/G electrophoresis
None	1.93	4.23	145	3.2	.13
20 mg <i>d</i> -alpha tocopheryl acetate	2.52	6.86	125	4.0	.42
1 ppm Se (sodium selenate)	2.12	6.37	120	3.8	.30
.5 ppm <i>idem</i>	2.37	5.27	126	3.9	.33
.1 ppm "	2.46	6.71	133	4.2	.42
1 ppm Se (sodium selenite)	2.26	6.36	145	4.0	.43
10% dried brewers yeast	2.87	6.76	116	4.4	.58
Dried brewers yeast ash (equivalent to 10% dried brewers yeast)	1.81	4.52	100	3.5	.29
.5 ppm Se (free selenium)	2.48	5.88	124	3.4	.21

yeast exert any effect pertaining to hemoglobin formation other than protection of the birds from the hemorrhaging which occurs in exudative diathesis.

Total serum protein levels were elevated by addition of Vit. E, selenium, as the selenate at all 3 of the levels tested, as the selenite, and by 10% dried brewers yeast (Table IV). No increase was noted after the feeding of dried brewers yeast ash or selenium as the free metal. A/G ratios, as determined by electrophoresis, were again increased with Vit. E, the 3 levels of selenate added to the diet, the selenite and 10% dried brewers yeast. Only a slight improvement with regard to A/G ratio was noted upon feeding 10% dried brewers yeast ash, as was also true with the addition of 0.5 ppm selenium. Selenium, as selenate, at a level of 1 ppm was apparently not as effective and perhaps was detrimental as compared to the level of 0.1 ppm. The A/G ratio obtained with 1 ppm selenium from selenate was 0.30. The A/G ratio obtained with 0.1 ppm was 0.42 which was identical to that obtained with 20 mg *d*-alpha tocopheryl acetate per lb of feed. The feeding of 10% dried brewers yeast resulted in an A/G ratio of 0.58 which was the highest obtained in this study.

The results of these studies show that addition of selenium to the Torula yeast basal diet will result in protection of the birds against symptoms of exudative diathesis, as reported by Scott(1). Free selenium appears to be only partially effective in overcoming the symptoms. The addition of a smaller quantity of selenium as selenate (0.1 ppm) will produce changes, with regard to red

blood cell counts, hemoglobin, total serum protein, and A/G ratios, identical to those obtained by the feeding of 20 mg of *d*-alpha tocopheryl acetate per lb of Torula yeast basal diet. These data indicate that 1 ppm of selenium as selenate was toxic and therefore, even though protection was obtained from the gross symptoms of exudative diathesis, the blood components studied were adversely affected as a result of the toxicity of the selenium rather than by a Vit. E deficiency.

Summary. Two experiments have been conducted with White Rock and New Hampshire chicks concerning effects of selenium, Vit. E and dried brewers yeast on occurrence of exudative diathesis, and of these substances on blood changes associated with Vit. E deficiency. Selenium (selenate) at 0.1 ppm was effective in reversing the lowered red blood cell counts, lowered hemoglobin values, lowered serum protein levels, and the reduced A/G ratios associated with exudative diathesis. As this level was increased to 1 ppm the total blood changes were not as greatly affected as with feeding of 0.1 ppm level, apparently due to the toxicity of selenium.

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Blood and Urine Tyrosine Levels in Starved X-irradiated Rats. (23816)

A. J. LUZZIO, G. SUTTON, AND J. G. KERIAKES (Introduced by A. T. Krebs)

Radiobiology Department, U. S. Army Medical Research Laboratory, Fort Knox, Ky.

Davy(1) reported that dogs exposed to a 500 r dose of x-rays showed immediate fall in serum albumin with return to normal after 48 hours. Muntz, Barron and Prosser(2) indicated that a lethal total body dose of x-rays

produced, in dogs, no characteristic changes in plasma protein pattern after one week following radiation. Thereafter, until death of the animal the serum proteins diminished steadily. Similar decreases in serum proteins