

Effect of Supplemental Vitamin E and Selenium in High Moisture Corn Diets on the Incidence of Mulberry Heart Disease and Hepatosis Dietetica in Pigs

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ABSTRACT

Forty-eight intact male pigs were used to investigate the influence of source of protein supplement, corn moisture content, and supplemental vitamin E-selenium on the incidence of mulberry heart disease, hepatosis dietetica and associated lesions. Pigs fed soybean meal-high moisture corn diets survived fewer days than pigs fed the other diets. None of the pigs fed torula yeast-dry corn or soybean meal-high moisture corn without supplemental vitamin E-selenium survived the 13 week trial. Supplemental vitamin E-selenium increased survival of pigs. A higher incidence of hepatosis dietetica, myocardial degeneration, skeletal muscle degeneration, and exudative diathesis was observed in pigs fed torula yeast-dry corn or soybean meal-high moisture corn than pigs fed soybean meal-dry corn. Supplemental vitamin E-selenium resulted in a reduction in the incidence of the above lesions by approximately 50% with the exception of hepatosis dietetica. Tissue selenium concentration did not appear to be related to the incidence of the various lesions.

RÉSUMÉ

Les auteurs ont utilisé 48 jeunes verrats pour étudier l'influence de la nature du supplément protéique, du degré d'humidité du

maïs et de l'enrichissement de la ration avec de la vitamine E et du sélénium, sur la fréquence de la cardiopathie mûriforme, de l'hépatose diététique et des lésions qui accompagnent ces troubles. Les sujets nourris avec du tourteau de soya et du maïs à fort pourcentage d'humidité survécurent quelques jours de moins que ceux à qui on servait les autres diètes. Aucun des sujets nourris avec de la levure torula et du maïs sec ou avec du tourteau de soya et du maïs à fort pourcentage d'humidité, sans addition de vitamine E et de sélénium, ne vécut jusqu'au terme d'une expérience de 13 semaines. L'addition de vitamine E et de sélénium à la ration prolongea la survie des porcelets. On observa plus de cas d'hépatose diététique, de dégénérescence du myocarde, de dégénérescence des muscles squelettiques et de diathèse exsudative chez les sujets nourris avec de la levure torula et du maïs sec ou avec du tourteau de soya et du maïs à fort pourcentage d'humidité que chez les porcelets nourris avec du tourteau de soya et du maïs sec. L'addition de vitamine E et de sélénium réduisit d'environ 50% la fréquence des troubles énumérés plus haut, à l'exception de l'hépatose diététique. La teneur des tissus en sélénium ne semblait pas reliée à la fréquence des différentes lésions.

INTRODUCTION

A wide spectrum of lesions has been associated with vitamin E and/or selenium deficiency in swine (1, 6, 8). Mulberry heart disease (MHD), hepatosis dietetica (HD), skeletal muscle degeneration (SMD), and exudative diathesis (ED) were the most commonly observed conditions (1, 4, 5, 6, 7). Various dietary treatments were used to induce these conditions, e.g. high

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levels of unsaturated fats (1, 5, 6) and torula yeast (4, 7). A high incidence of HD, MHD, SMD and ED was observed in pigs fed a torula yeast-corn diet in a previous experiment (8). All of these diets contained ingredients not commonly used in swine rations under natural feeding conditions. A high frequency of the above-mentioned conditions were observed in pigs fed a soybean meal-high moisture corn diet, which is now commonly fed to pigs in Ontario. The objective of this research was to evaluate the effect of vitamin E and selenium supplementation of dystrophogenic diets fed to pigs.

MATERIALS AND METHODS

Forty-eight intact male Yorkshire pigs averaging 7.6 kg were stratified by weight into eight groups and randomly assigned from within groups to six treatments. The trial consisted of a 3 x 2 factorial randomized complete block arrangement with eight replications. The factors were three types of diet with or without vitamin E-selenium (E-Se) supplementation (Table I). The pigs were maintained in group pens, four pigs receiving the same diet per pen, and were fed in individual feeding stalls. The commercial E-Se supplemented diets were fed according to the supplement manufacturers' suggestions during the second, sixth and tenth week of the 13 week trial and the comparable non-supplemented diets were fed during the intervening weeks.

The high moisture corn was from the same harvest as used previously (8). The "regular" corn was harvested from the same crop but artificially dried before storage. The torula yeast and soybean meal were obtained commercially. Necropsy was performed on all pigs. Pigs which completed the trial were electrocuted. Tissue samples were obtained from all pigs for histology and chemical analysis. Sections of skin, myocardium, liver, skeletal muscle, semitendinosus, colon, bladder, lung, kidney and marrow were fixed in 10% formalin, paraffin embedded, histological sections cut at 5 μ and stained with hematoxylin and eosin. Chemical analyses were according to procedures outlined previously (8) with the exception of ubiquinone which was analyzed according to the procedure of Mervyn and Morton (3).

RESULTS

SURVIVAL

Pigs fed the unsupplemented soybean meal-high moisture corn diet (1266) survived fewer days than pigs fed the other diets (Table II). The pigs fed this diet survived an average of 18.5 days. The first death occurred on the 13th day of the trial. Pigs fed the unsupplemented torula yeast diet survived an average of 42.1 days (1263). Supplementation of diets containing torula yeast or high moisture corn with E-Se increased survival considerably where-

TABLE I. Composition of Experimental Diets^a

Diet Number	1262	1263	1264	1265	1266	1267	Supplement 1	Supplement 2
Ingredient								
Corn (regular).....	77.7	77.9	77.0	77.2			0.8	
Corn (high moisture).....					75.0	75.0		
Torula yeast.....	19.0	19.0						
Soybean meal.....			19.2	19.2			84.8	84.8
Vitamin premix 1003 ^b	0.5	0.5	0.5	0.5			2.0	2.0
Trace mineral premix 1004 ^b	0.1	0.1	0.1	0.1			0.4	0.4
Cobalt iodized salt.....	0.5	0.5	0.5	0.5			2.0	2.0
Calcium phosphate.....	0.5	0.5	1.3	1.3			5.2	5.2
Limestone.....	1.5	1.5	1.2	1.2			4.8	4.8
Vitamin E-Se premix ^c	0.2		0.2					0.8
Supplement ¹					25.0			
Supplement ²						25.0		

^aPercentage on a dry basis

^bSee Sharp et al (8) for composition of the vitamin and trace mineral premixes

^cEphos powder Bristol Laboratories of Canada Ltd., St. Hyacinthe, Quebec. Contains 3.5 I.U. of α -tocopherol acetate and 0.076 mg of selenium sulfide per gram. Fed to supply 70.5 I.U. α -tocopherol acetate and 0.141 mg selenium sulfide per kg of complete diet

as there was less improvement in survival due to supplementation of pigs fed soybean meal-regular corn diets. Pigs fed soybean meal-regular corn diets survived the longest. None of the pigs fed the unsupplemented torula yeast or soybean meal-high moisture corn diets survived the trial.

The greatest survival was in pigs which received the most selenium per kg gain. Pigs fed the unsupplemented soybean meal-regular corn diet (1265) or the unsupplemented soybean meal-high moisture corn diet (1266) had similar intakes of selenium per kg of body weight and more than pigs fed torula yeast regular corn diets. Vitamin E intake per kg of gain for the unsupplemented diets was highest for the torula yeast followed by the soybean meal-regular corn and soybean meal-high moisture corn fed pigs.

The tocopherol content of the unsupplemented diet containing soybean meal and high moisture corn (2.54 ug/g) was about one-half that of the diet containing soybean meal and regular corn.

PATHOLOGICAL LESIONS

Various pathological lesions were observed in all treatments (Table III) however there was an apparent higher frequency of MHD and SMD in pigs fed diets containing torula yeast or high moisture

corn. The E-Se supplement did not appear to influence the frequency of HD.

Fewer pigs survived and more lesions, especially myocardial and skeletal muscle degeneration, were observed in pigs fed diets containing high moisture corn or torula yeast (Table IV). There was a higher frequency of exudative diathesis and mortality in pigs fed diets containing high moisture corn, as compared with pigs fed diets containing torula yeast or regular corn-soybean meal.

Supplementation of the pigs for one week out of four with the E-Se supplement reduced the frequency of all but liver lesions by approximately 50%. However, lesions were also observed in supplemented pigs. In the supplemented group the liver lesions consisted of post necrotic scarring and nodular hyperplasia.

All the pigs which died, and some surviving pigs, exhibited myocardial degeneration. The myocardial lesions were similar to those described for mulberry heart disease. A detailed morphological description of the various lesions which were observed will be published in this journal at a later date.

TISSUE ANALYSIS

Pigs fed the torula yeast diet had significantly lower selenium concentrations in

TABLE II. Performance and Survival of Pigs Fed Vitamin E and Selenium

Diet Number	1262	1263	1264	1265	1267	1266
Vit. E-Se Supplement	+	-	+	-	+	-
Av. daily gain kg ^a	0.13 ¹	0.10 ¹	0.13 ¹	0.15 ¹	0.23 ²	0.20 ²
Av. daily feed kg dry matter ^a	0.35	0.33	0.38	0.36	0.37	0.37
Gain/feed ^a	0.37 ¹	0.29 ¹	0.32 ¹	0.37 ¹	0.63 ²	0.53 ²
Survival						
Mean days.....	71.1	42.1	83.5	72.9	68.8	18.5
Survival/total pigs.....	5/8	0/8	7/8	5/8	5/8	0/8
Feed selenium µg/g dry matter.....	0.05	0.02	0.09	0.03	0.07	0.04
Feed tocopherol µg/g dry matter.....	51.12	7.55	50.31	5.57	53.54	2.54
Intake						
µg Se/kg gain ^a	99.47 ²	66.54 ¹	137.35 ³	91.36 ²	126.48 ³	74.88 ¹
µg Se/kg gain ^b	83.01 ¹	12.58 ²	45.40 ³	114.35 ²	25.66 ¹	100.68 ³
µg Se/kg body wt ^a	24.82 ¹	18.70 ¹	35.53 ^{1,2}	69.24 ⁴	46.29 ²	23.35 ¹
µg Se/kg body wt ^b	18.70 ¹	28.39 ²	55.57 ¹	15.56 ³	49.63 ¹	4.81 ³
mg E/kg gain ^a	52.26 ¹	50.01 ¹	35.56 ²	4.37 ³	19.38 ¹	1.50 ⁴
mg E/kg gain ^b	17.84 ^{1,2}	5.37 ³	16.47 ²	10.42 ¹	10.44 ¹	
mg E/kg body wt ^a	17.84 ^{1,2}	5.37 ³	16.47 ²	10.42 ¹	19.38 ¹	1.50 ⁴
mg E/kg body wt ^b	11.60 ¹					

^aFirst three weeks of trials

^bMean intake for diet during first three weeks of trial

^{1, 2, 3} - means bearing different superscripts differ significantly (P = 0.05)

liver, kidney, heart and muscle than those pigs fed the soybean meal-high moisture corn diet (Table III). The tissues, except kidney, from pigs fed regular corn-soybean

meal diets tended to have intermediate selenium values between the torula yeast and high moisture corn fed pigs, but were not significantly different from either ex-

TABLE III. Vitamin E, Selenium and Ubiquinone Concentrations of Selected Tissues and Diets* and Pathological Lesions Associated with the Individual Diets

Diet Number	1262	1263	1264	1265	1267	1266
Vit. E-Se Supplement ^b	+		+		+	
Feed selenium.....	0.06	0.02	0.08	0.03	0.07	0.03
Feed tocopherol.....	51.12	7.55	50.31	5.57	53.54	2.45
Selenium						
liver.....	0.17	0.18	0.19	0.28	0.31	0.28
kidney.....	1.67	1.27	2.77	2.48	2.69	1.85
heart.....	0.15	0.22	0.22	0.26	0.31	0.32
muscle.....	0.08	0.14	0.14	0.14	0.18	0.19
Ubiquinone						
heart.....	323.0	306.2	389.6	348.14	342.6	310.0
liver.....	155.6	131.3	141.3	147.3	153.3	157.4
Selenium						
liver ^c	0.18 ¹		0.23 ^{1,2}		0.30 ²	
kidney ^c	1.42 ¹		2.63 ²		2.27 ^{2,3}	
heart ^c	0.19 ¹		0.24 ^{1,2}		0.31 ²	
Ubiquinone						
heart ^c	314.6		369.0		326.3	
liver ^c	143.5		144.5		155.3	
Skin macules ^d	1/8	4/8	1/8	1/8	2/8	6/8
Exudative diathesis ^d	3/8	4/8	1/8	2/8	3/8	8/8
Myocardial degeneration ^d	3/8	8/8	2/8	3/8	3/8	8/8
Skeletal muscle degeneration ^d	3/8	7/8	2/8	3/8	3/8	6/8
Microangiopathy ^d	3/8	8/8	1/8	3/8	3/8	8/8
Hepatosi dietetica ^d	4/8	4/8	1/8	5/8	3/8	1/8
Erosions and/or ulcers of pars esophagia ^d	4/8	4/8	1/8	5/8	3/8	1/8

*Data expressed as µg/g dry basis

^bSupplement fed during the second, sixth and tenth week of the 13 week trial (70.5 IU tocopherol acetate and 0.141 mg selenium sulfide per kg of complete diet)

^cMean for pigs fed the same protein supplement

^dNumber of pigs exhibiting the lesions over total number of pigs in the treatment

TABLE IV. Frequency of Lesions and Survival of Pigs Associated with Different Diets and Supplements

Variable	Survival/ Total	Hepatosi Dietetica	Myocardial Degeneration	Skeletal Muscle Degeneration	Exudative Diathesis
Diet					
Torula yeast.....	5/16	10	11	10	7
Soybean meal + regular corn.....	12/16	4	5	5	3
Soybean meal + high moisture corn.....	5/16	7	11	9	11
Supplement E + Se					
+.....	17/24	10	8	8	7
0.....	5/24	11	19	16	14
Survival					
Lived.....	—	7	1	2	0
Died.....	—	18	26	20	20

tremes. Pigs fed the diets containing soybean meal had higher kidney selenium contents than those fed torula yeast. The kidneys of pigs fed the E-Se supplement contained higher levels of selenium than that of pigs fed the comparable unsupplemented diet.

LIVE PERFORMANCE

Pigs fed the high moisture corn gained more rapidly during the first three weeks of the trial and were more efficient in converting feed to gain (Table II), than pigs fed the diets containing regular corn. No differences were observed in daily feed consumption. Supplemental E-Se during the second week of the trial did not improve rate of gain or efficiency of gain over non-supplemented pigs. Interpretation of subsequent live-performance data was made difficult due to the high mortality.

DISCUSSION

Since the soybean meal regular corn diet was intermediate between the soybean meal high moisture corn and the torula yeast regular corn diets in both selenium and α -tocopherol content, the difference in survival cannot be adequately explained by the level of either of these nutrients.

Based on the above data it is not clear whether vitamin E or selenium deficiency caused the death of the pigs. It is possible that two distinct but related deficiency diseases are being observed. In the case of the high moisture corn fed pigs, the incidence of death may be due to a deficiency of vitamin E while in the case of torula yeast fed pigs, death may be due to a selenium deficiency.

Since the unsupplemented soybean meal-high moisture corn diets contained approximately one-half the level of tocopherol as the unsupplemented soybean meal-regular corn diets, this may indicate a loss or destruction of tocopherol in high moisture corn during silo storage.

The observation that liver, heart and muscle tissue selenium concentrations were similar for supplemented as well as non-supplemented pigs could be due to the insolubility of selenium sulfide in water (9)

and, therefore, the inability of the pig to absorb the selenium from the gastro-intestinal tract. Hidiroglou *et al* (2) reported similar results when feeding the same commercial supplement to young calves. Therefore, the protective effect observed due to the supplement may be due to its content of vitamin E. The apparent relationship between selenium intake per kg gain and survival referred to earlier may be only coincidental.

Since pathological lesions were observed in pigs supplemented with vitamin E and selenium, the amount or method of supplementing were inadequate to render complete protection or the lesions observed were not solely due to a deficiency of vitamin E and/or selenium.

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