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SUMMARY

A study was made of the vitamin E content of each of the ingredients of our dairy herd ration, excepting the salt, lime, and bone meal. Female rats which were able to conceive but unable to reproduce when fed a diet deficient in vitamin E were fed the various feeds as a source of vitamin E during a second breeding period. The presence of vitamin E in a feed was thus shown by the ability of the female to cast a litter. The vitamin E content of bran, shorts, linseed oil meal, hominy feed, white corn, yellow corn, cottonseed meal, kafir, beet pulp, corn gluten feed, corn gluten meal, and alfalfa was examined. Twenty to twenty-five per cent of the bran, shorts, linseed oil meal, hominy feed, white corn, yellow corn, cottonseed meal, kafir, or alfalfa furnished sufficient vitamin E to allow the rats to cast litters. On the other hand, forty per cent of the corn gluten meal, the corn gluten feed, or the beet pulp furnished very little vitamin E. There was no significant difference in the vitamin E content of the white and yellow corn used.

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Difficulties in breeding with the dairy herd at the University of Nebraska have been experienced to a greater or less degree for nearly a third of a century. It is well known that there are many factors which lead to delayed pregnancy. The studies of Evans and Bishop (3), of Sure (11), and of Mattill and Stone (10), which have since been confirmed by many investigators, showed that rats are unable to reproduce if maintained on a diet deficient in vitamin E. Although it has been assumed by many that dairy cattle require vitamin E for reproduction, as far as the writers are aware there have been no scientific investigations which have yet established this fact. In order to obtain some idea of the occurrence of vitamin E in our dairy herd ration and to obtain information which might serve as a foundation for studies of the vitamin E requirements of dairy cows, a study was made of the vitamin E content of each of the ingredients of the herd ration, excepting the salt, lime, and bone meal.

REVIEW OF LITERATURE

A review of the literature pertaining to diet and sterility has been prepared by Kennedy (7), and Evans (2) recently reviewed the literature regarding vitamin E. Only material pertinent to our experiments is presented here. Evans and Burr (4) reported that vitamin E was present in animal tissues, bananas, lettuce, tea, peas, cotton, oats, corn, wheat, and alfalfa but was not found in abundant quantities in butter, Crisco, walnut oil, or cod-liver oil. Sure (12) studied the distribution of vitamin E in a number of oils and feed materials. He found this vitamin in olive, peanut, soy-bean, peach-kernel, palm, cottonseed, wheat, and corn oil. Linseed, cocoanut, sesame, palm-kernel, rape-seed, mustard-seed, and commercial corn oil (Mazola) and oil of sweet almonds were found deficient in antisterility properties. Kennedy (8) reported that crushed oats contain vitamin E.

EXPERIMENTAL PROCEDURE

The dairy herd ration was composed as follows:

Dairy Herd Ration

Corn	200 lbs.	Beet pulp	100 lbs.
Oats	200 lbs.	Cottonseed meal	50 lbs.
Bran	150 lbs.	Salt	10 lbs.
Hominy	50 lbs.	Lime	10 lbs.
Linseed oil meal	50 lbs.	Bone meal	5 lbs.
Gluten feed	100 lbs.		

The average daily feed consumption per cow was approximately 20 to 25 pounds of silage, 5 to 20 pounds of the grain mixture and 20 pounds of alfalfa hay.

The management of the rat colony was essentially the same as that outlined by Davis and Hathaway (1) except where otherwise indicated. The breeding stock was maintained on the Steenbock Stock Ration, composed as follows:

Stock Ration 1

Yellow corn	76.0%	Ground alfalfa	2.0%
Linseed oil meal	16.0%	Sodium chloride	0.5%
Crude casein	5.0%	Calcium carbonate	0.5%

The materials were finely ground and then 5 per cent by weight of butter was added. In addition to this ration the animals received lettuce several times each week.

The rats used in these experiments were pied rats reared in our own laboratory. Female rats 24 to 28 days old, and weighing from 40 to 50 grams, were placed on a vitamin E deficient ration similar to that employed by Evans and Burr (5).

This ration was composed as follows:

Vitamin E Deficient Ration

Casein [1]	16%	Yeast [4]	14%
Corn starch [2]	40%	Cod-liver oil [5]	2%
Lard [3]	22%	Salts (McCollum No. 185)	4%

This ration has been fed to 225 females at this Station and in no instance has initial fertility been encountered. Evans and Burr (5) obtained only four cases of initial fertility when a similar ration was fed to 200 females.

The females were maintained on this ration until they were 90 to 120 days old and then mated for a period of 15 days to stock males previously shown to be fertile by matings with stock females. Each female was weighed three times per week during this period of mating and until 21 days after separation from the males. During this period of mating as well as during the second mating period the males were allowed only the feed allotted to the females. Only those females which showed resorption of a fetus as evidenced by

[1] Purified casein (No. 453) was purchased from the Casein Company of America, New York City. It was extracted continuously for five days with 95 per cent ethyl alcohol.

[2] Powdered starch was obtained from the Corn Products Refining Company, New York City.

[3] Star Lard was purchased locally from Armour & Company.

[4] Compressed yeast was furnished through the courtesy of the Standard Brands, Inc. It was dried in a current of air at room temperature, finely ground, and fed without further treatment.

[5] Standardized cod-liver oil from Mead, Johnson & Company, Evansville, Indiana, was used.

their weight curve were used for the vitamin E tests. The weight curve of the pregnant female on a normal ration generally shows a steady rise until parturition, at which time there is a precipitous fall in the curve. On the other hand the weight curve of the pregnant female on a vitamin E deficient ration shows a steady rise until about the fourteenth day. From this time on there is a gradual diminution in weight and the period of gestation passes without a litter being cast. During this selection 27 females were discarded, as it was not evident from the weight curve whether or not they had resorbed a fetus.

Beginning with the twenty-second day after the males were removed from the females, the various feeds were incorporated into the vitamin E deficient ration. This was accomplished by replacing a portion of the corn starch with an equal quantity of the finely ground feed. After the females had been on the supplemented ration for four days they were again mated. During this second gestation period the females were weighed daily and watched closely to detect parturition. As our cages were not equipped with any special device, such as the one described by Long and Evans (9), for determining the number of young dropped, our counts may not be accurate since some pups are at times devoured by the mother shortly after birth. In six cases it was not possible to determine whether a litter had been dropped or a resorption had taken place. These cases, therefore, were not considered in the tabulations.

The results obtained are shown in Table 1. Since previous studies from this laboratory (6) showed that 20 per cent of alfalfa as a source of vitamin E resulted in good reproduction, the group of rats receiving 20 per cent of ground alfalfa was included in these experiments as a positive control group. The negative control group received only the vitamin E deficient ration. Since none of the females used in these studies dropped a litter during the first gestation period, it was evident that the basal ration was deficient with respect to vitamin E and therefore only three females were allotted to the negative control group.

The bran and shorts were fed at 20 per cent levels, while the linseed oil meal, hominy feed, white corn, cottonseed meal, kafir, and yellow corn were fed at 25 per cent levels. Since this vitamin is a fat-soluble one and since the corn gluten meal, the corn gluten feed, and the beet pulp contained only from 0.5 to 1 per cent of fat, according to the manufacturers' analysis, these feeds were fed at 40 per cent levels.

TABLE 1.—*Summary of the number of litters dropped by rats fed various feeds as sources of vitamin E*

Source of vitamin E	Levels	Females in group	Litters dropped	Resorptions	Young dropped
	P. ct.	*No.*	*No.*	*No.*	*No.*
Alfalfa (ground)	20	18	18	0	132
Bran (wheat)	20	19	18	1	158
Shorts (wheat)	20	20	18	2	181
Linseed oil meal	25	20	19	1	185
Hominy feed (white)	25	17	16	1	129
Corn (white) (Iowa Silvermine)	25	19	19	0	168
Cottonseed meal	25	20	19	1	156
Kafir (red)	25	20	20	0	166
Corn (yellow) (Cattle corn)	25	19	17	2	160
Beet pulp	40	19	2	17	12
Corn gluten feed	40	18	1	17	10
Corn gluten meal	40	18	0	18	0
Vitamin E deficient ration	100	3	0	3	0

It will be noted that each of the females in the alfalfa, white-corn, and kafir groups produced a litter and that all of the females, excepting one, in each of the bran, linseed-oil-meal, hominy-feed, and cottonseed-oil-meal groups produced litters. All of the females, excepting two, in each of the shorts and yellow-corn groups produced litters. On the other hand, no litters were produced in either the corn-gluten-meal or the vitamin-E-deficient-ration groups, only one litter in the corn-gluten-feed group and only two litters in the beet-pulp group. Since practically all of the females in the alfalfa, bran, shorts, linseed-oil-meal, hominy-feed, white-corn, cottonseed-meal, kafir, and yellow-corn groups produced litters, it is evident that these amounts of these feeds furnished sufficient vitamin E for reproduction in rats. The results obtained with the pure strains of white and yellow corn indicate that vitamin E, unlike vitamin A, occurs in white as well as in yellow corn.

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