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Effect of Potassium Nitrate Intake on Lactating Dairy Cows

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SUMMARY

Administration of KNO_3 to lactating dairy cows resulted in a decrease in milk production and an increase in methemoglobin, which varied according to the level of KNO_3 intake. KNO_3 ingestion apparently had no adverse effect on milk composition (butterfat, total solids, solids-not-fat and chlorides).

Death of one experimental cow resulted from an intake of 25 grams KNO_3/ 100 pounds body weight daily for three days.

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In recent drouth years, decreases in body weight gains and milk production of cattle frequently have been attributed to increased nitrate intake (5, 15). Toxicity symptoms of nitrate poisoning have been described by Davidson, *et al.* (7), as being characterized by rapid acceleration of the pulse, followed by short, quickened respiration, trembling of certain muscles, weakness, staggering gait, and apparent blindness in some cases. Cyanosis of tongue and schlera occurs, and death takes place with little or no struggling. These observations are in general agreement with those reported by Muhrer, *et al.* (14), and Beath, *et al.* (3).

The nitrates are thought to be reduced to nitrites in the rumen and pass into the blood stream where they act as oxidizing agents, changing the hemoglobin to methemoglobin (8), thus decreasing the amount of oxygen available to the tissues. Lewis (11) indicates that nitrite is an intermediate in the conversion of nitrate to ammonia. Benedet, (4) working with rabbits, found that nitrite produced hemolysis of the red corpuscles, disturbed the oxygen carrying power, and caused severe renal and pulmonary changes when given intravenously for an extended period; while Herzfeld and Kruger (10) found that blood sugar is first lowered and then elevated above normal by nitrite in both men and animals. Methemoglobin concentrations were found inversely related to the blood levels of ergothionine and glutathione by Mortenson (12).

Barnett and Bowman (2) used six artificial rumens to study the action of nitrates on various substrates. Nitrite formation was found to be most vigorous when dried grass or grass pigments (containing potential hydrogen donors) were present.

The composition, nature, and level of the diet apparently influences nitrate sensitivity in ruminants. Muhrer, *et al.* (13), concluded that the effects of low levels of KNO_3 (.75%) on milk production could largely be reversed by the addition of 6 percent molasses to the diet. When 30 grams of glucose were added to the ration of sheep receiving 20 grams of KNO_3 per 100 pounds body weight and poor quality grass hay, a milk methemoglobinemia was alleviated. When the same sheep received 30 grams of KNO_3 per 100 pounds body weight, severe symptoms of methemoglobinemia were produced but with simultaneous glucose feeding the results were less severe (17).

Whitehead and Moxon (17) have stated that 1 pound of KNO_3 for a 1000-pound animal will convert 70 to 80 percent of the hemoglobin to methemoglobin in a few hours; however, 200 to 300 grams of KNO_3 have been reported to cause death of animals weighing up to 1200 pounds within 4 to 15 hours (1).

Bradley, *et al.* (5), on the basis of toxic hay experiments, concluded that 1.5 percent KNO_3 was the lower limit for toxic hay. These differences may be due to the plane of nutrition and milk production levels.

MATERIALS AND METHODS

Healthy, lactating cows were chosen from the University dairy herd for use in the nitrate experiments. The normal diet for the animals was alfalfa hay and corn silage, *ad libitum,* and 1 pound of a grain mixture for each 3 pounds (Jerseys) or 4 pounds (Holsteins) of milk produced daily. The composition of the grain mixture was: 500 pounds corn (No. 2 yellow), 500 pounds hominy (5% or more fat), 250 pounds oats, 300 pounds wheat bran, 300 pounds soybean oil meal (44%), 100 pounds beet pulp (molasses dried), 20 pounds steamed bone meal (10-20% protein), and 30 pounds salt.

Potassium nitrate was administered to experimental animals by stomach tube or in gelatin capsules following the morning milking.

Experimental cows were fed and milked with the regular milking herd and milk weights were recorded at each milking. Composite milk samples were made, consisting of aliquot parts of the two milkings following KNO_3 administration. Milk samples were kept cool overnight and the tests were run as soon as possible the next morning. Between tests, the samples were kept in the refrigerator and all determinations were completed within 12 hours following the morning milking. Tests were run on each cows' milk once a week throughout the experimental period.

The butterfat tests were run according to the standard Babcock procedure, while the total solids were determined by the Majonnier method.

A modification of the Volhard titration method without preliminary digestion was used to determine the chloride content of the milk samples (16). A 17.5 ml. sample of milk was pipetted into a 200 ml. erlenmeyer flask. Twenty ml. of special silver nitrate solution were added to the sample and mixed with the milk by rotating the flask. The excess silver nitrate in the mixture was titrated with a solution of potassium sulfocyanate to a blood red end point.

Blood samples (15-20 ml.) were obtained from the jugular vein and were stored (1-2 hours) in tightly stoppered test tubes at refrigerator temperatures until hemoglobin and methemoglobin was determined. The method of Evelyn and Malloy was used to determine the hemoglobin and methemoglobin values for the blood; calibration factors were determined by the Wong method (9). A Coleman No. 14 Spectrophotometer was used to determine optical density of the samples.

Samples of blood were taken prior to weekly nitrate administration and at two-hour intervals following nitrate dosages until methemoglobin values began to decline, 6 to 7 hours following KNO_3 ingestion. Less frequent blood samples were taken when daily dosages of nitrate were given. Each morning a blood sample was drawn before nitrate administration to determine possible carryover of methemoglobin from the preceding day. Another blood sample was taken at the estimated peak conversion of hemoglobin to methemoglobin and a third sample was drawn two hours later to obtain the decline in methemoglobin formation.

RESULTS AND DISCUSSION

Standard hemoglobin values obtained by the Wong method averaged 12.15 mg/100 ml. of whole blood. This value was slightly higher than that found by Byers, *et al.* (6), but very similar to the one reported by Dukes (8). In all cases, after KNO_3 was administered, no methemoglobin could be detected by the following morning.

In Trial I, three cows served as control and three as experimental animals. Each cow received increasing amounts of nitrate (2.5 to 25.0 grams KNO_3/cwt.) once a week for the eight-week experimental period. Results of this trial are shown in Figure 1. The amounts of methemoglobin shown are an average of the values obtained at the different levels of nitrate administration. Milk production values represent the pounds of milk produced on the day following KNO_3 administration expressed as a percentage of the average daily production on the two days preceding KNO_3 intake. Milk production of the experimental cows declined as the level of KNO_3 intake increased. Sharp increases in milk production occurred when KNO_3 administration was stopped.

Methemoglobin values increased as the level of nitrate intake was raised and ranged from an average of 24 percent to 35.5 percent at the 25 grams KNO_3/cwt. level. Determination of chlorides, butterfat, total solids, and solids-not-fat indicated no major effect of nitrate intake on these constituents (Figure 2).

Levels of 25, 20, and 15 grams KNO_3/cwt. were given daily to cows No. 611, 602, and 375 respectively, with results as shown in Figure 3. The experimental cows showed a decrease in milk production and an increase in methemoglobin formation, while the control cows maintained (445) or increased (446, 590) milk production throughout the experiment. Cow No. 611 died after the third day of KNO_3 administration and was autopsied at the University Veterinary Clinic. Methemoglobin reached 90 percent shortly before death, and anoxia was the apparent cause of death. The symptoms in this case were in agreement with those of Davidson, *et al.* (7) and Muhrer, *et al.* (14).

Nitrate dosages were discontinued on cow No. 602 to prevent death, but cow No. 375 was kept at the 15 grams KNO_3/cwt. level for the remainder of the experiment except for one day when she received 20 grams/cwt. Methemoglobin on the two days following the 20 grams/cwt. dose was considerably above that found during the first seven days of treatment. Milk production of cow No. 375 continued to decline until the end of the experiment; however, she then began to increase her production and within three weeks had returned to a level equal to that at the start of Trial II. Cow No. 602 began increasing her milk production immediately after nitrate administration was stopped.

Table 1 shows the response of individual animals to KNO_3 administration under different nutritional conditions. All animals received the indicated amounts of feed for a period of 19 days, and 15 grams KNO_3/100 pounds body weight were given daily to each cow during the last five days. The results suggest that

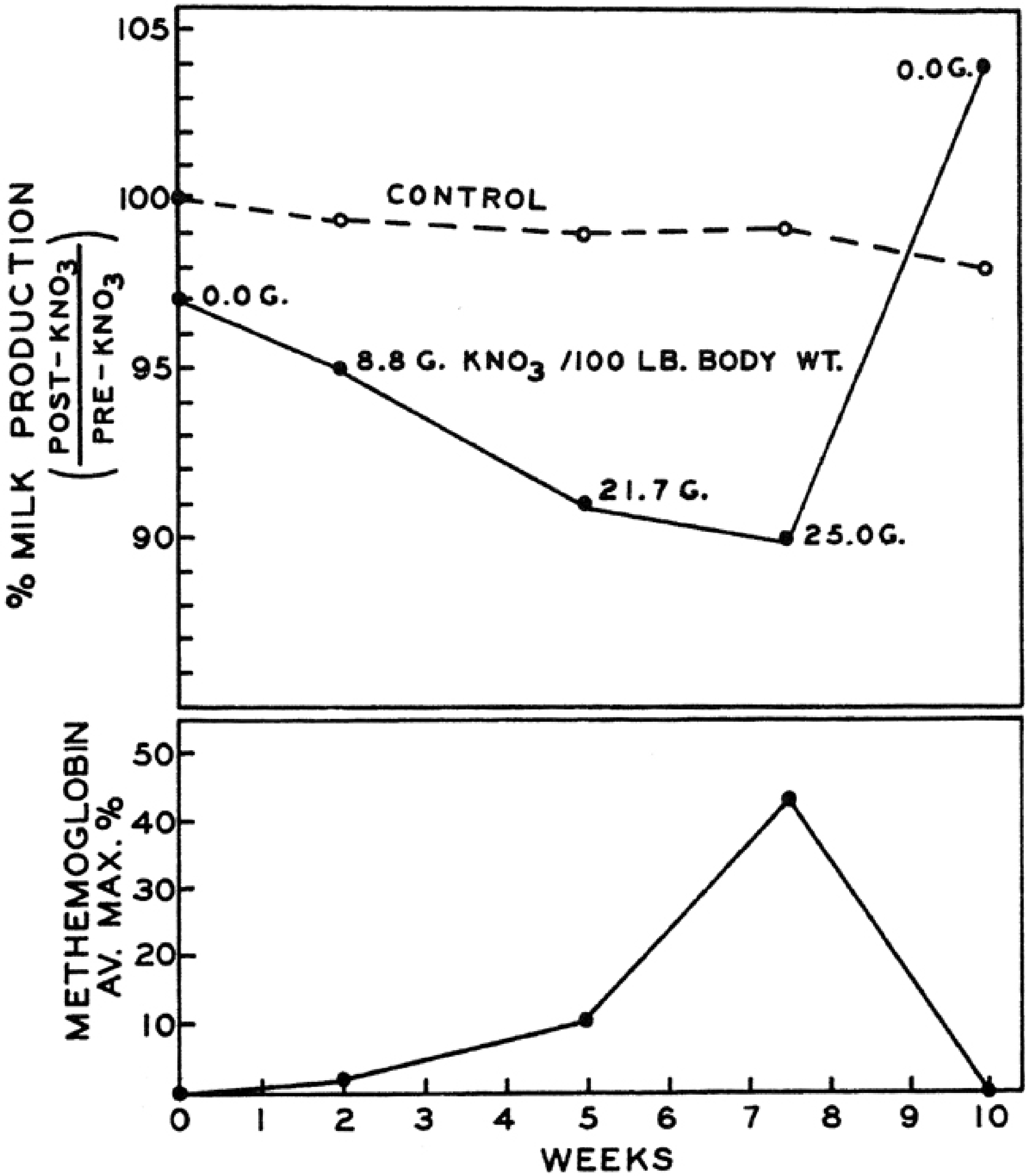

Fig. 1—The effect of single dosages of KNO_3 on lactating dairy cows. Average values for 3 experimental and 3 control animals.

high producing cows are more sensitive to the effects of KNO_3 administration; however, previous history of the animal is also important since those animals which had not received KNO_3 in earlier experiments were more sensitive. Nutritional level in these experiments showed little, if any, effect on response to the administration of KNO_3.

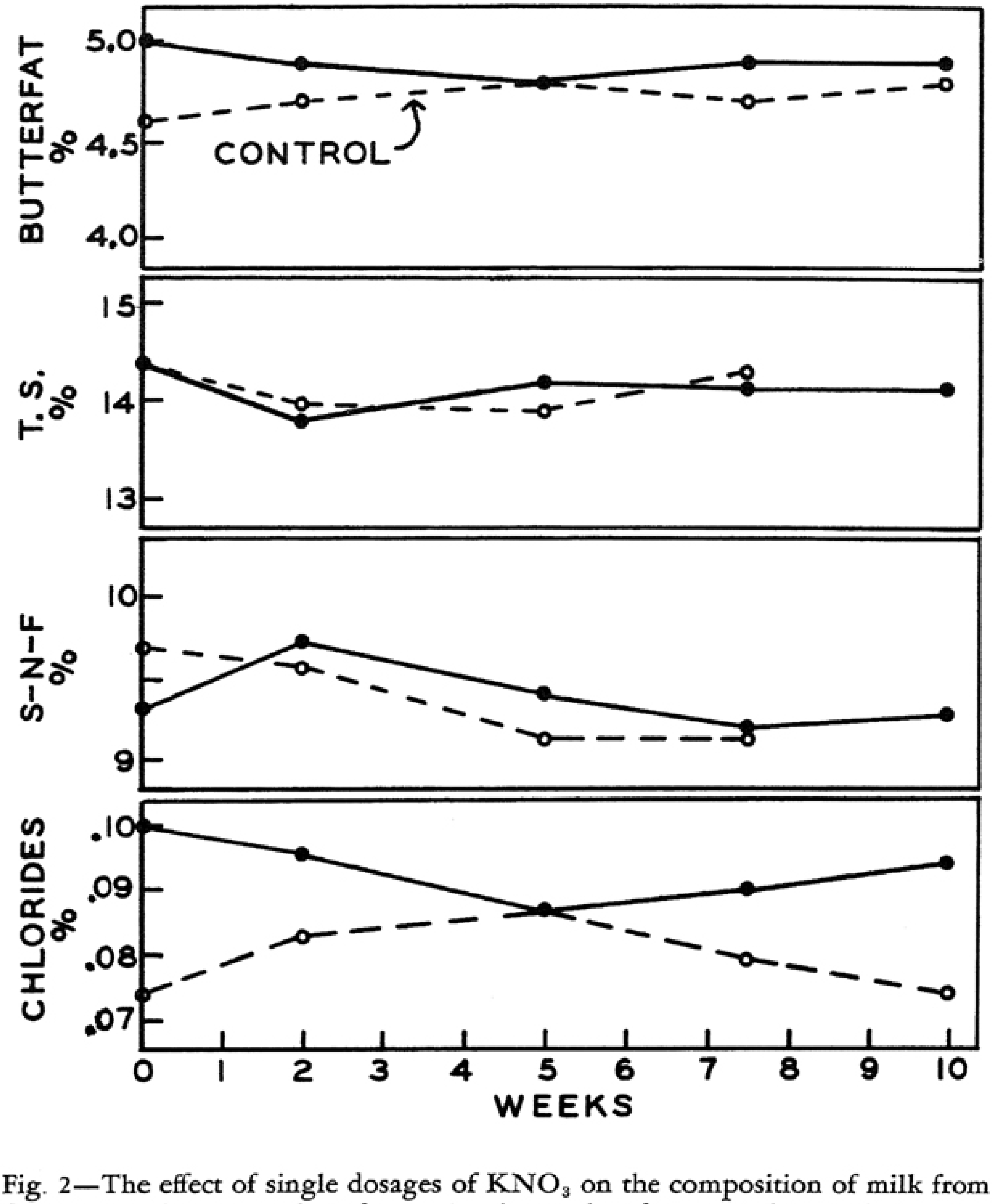

Fig. 2—The effect of single dosages of KNO_3 on the composition of milk from dairy cows. Average values for 3 experimental and 3 control animals. Experimental animals received an average of 0.0, 8.8, 21.7, 25.0, and 0.0 g. KNO_3/100 lbs. body wt. at 0, 2, 5, 7.5, and 10 weeks respectively.

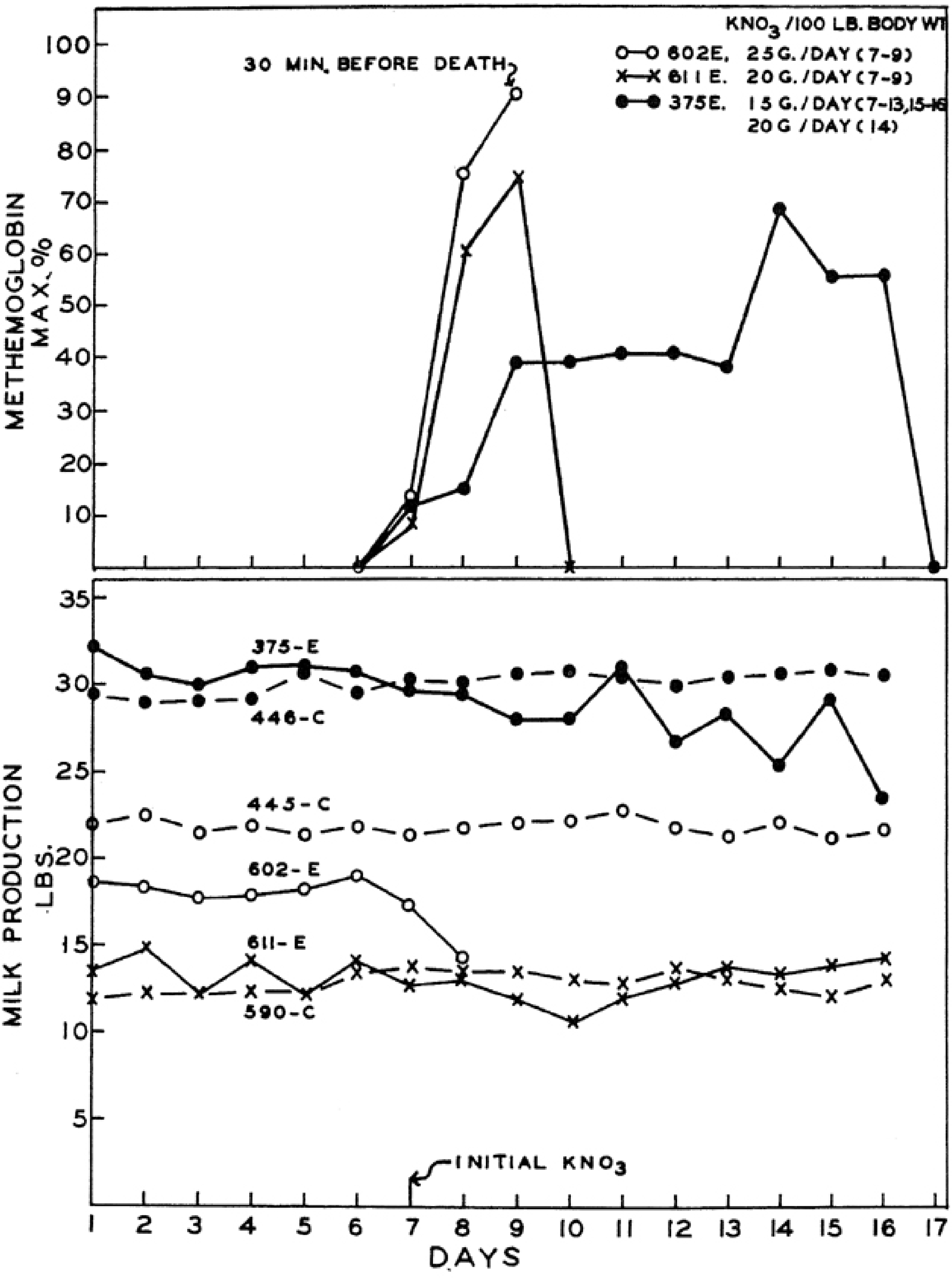

Fig. 3—The effect of daily KNO_3 intake on milk production and methemoglobin formation in dairy cows.

TABLE 1--THE EFFECT OF LEVEL OF FEED INTAKE ON THE RESPONSE OF LACTATING COWS TO DAILY INTAKE OF 15 g. KNO_3/100 LBS. BODY WT.

Cow No.	446	375	445	602	590
Feed intake (% of normal ration)	100	75	50	75	50
Previous KNO_3 administration	-	+	-	+	-
Av. daily milk prod.					
5 day - Pre KNO_3	25.2	24.5	11.6	10.3	8.0
5 day - KNO_3	20.6	22.1	8.2	10.7	7.7
Dif. - lbs.	- 4.6	-2.4	- 3.4	+ .4	- .3
%	-18.25	-9.80	-29.31	+3.88	-3.75
Max. % methemoglobin	40.0	31.0	69.0	23.0	29.0

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