UPTAKE AND EXCRETION OF CESIUM$^{134}$ AND POTASSIUM$^{42}$ IN LACTATING DAIRY COWS 1

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SUMMARY

Eight lactating dairy cows were each given 1 mc. of Cs$^{134}$ and 6 mc. of K$^{42}$ in a single oral dose. An average of 6.7% of the Cs$^{134}$ and 4.2% of the K$^{42}$ were secreted into milk in 66 hr. Corresponding values for urinary excretion were 19.0 and 38.0%. Averages of 10.5, 30.0, and 32.7% of the cesium$^{134}$ were found in milk, urine, and feces, respectively, in 210 hr. The variation in Cs$^{134}$ and K$^{42}$ secreted into milk can largely be explained on the basis of differing milk yields, with concentration remaining somewhat constant. The concentration of Cs$^{134}$ and K$^{42}$ in urine and the volume of urine are both highly variable.

The ingestion of contaminated foods is the principal source of Cs$^{137}$ in the population. Food is contaminated either through direct contamination or through plant uptake from soil. Anderson et al (1) have stated that the main source of Cs$^{137}$ in humans probably is cows' milk. Since cesium and potassium are, to a certain extent, similar in a chemical and physiological sense, the passage of radiocesium through biological systems has been expressed in terms of a Cs$^{137}$/K ratio. A radiocesium-radiopotassium ratio can be used to express differential passage.

The experiments reported in this paper have been conducted to gain knowledge on the relative passage of orally administered Cs$^{134}$ and K$^{42}$ through lactating dairy cows.

EXPERIMENTAL PROCEDURE

Two experiments involving four cows each were conducted, one in October, 1959, and the other in January, 1960. These cows were each given a single oral dose of 1 mc. of Cs$^{134}$ and 6 mc. of K$^{42}$. These amounts were necessary for detection in samples over a 210- and 66-hr. period, respectively. The Cs$^{134}$ was given carrier-free and 24.6 and 19.2 mg. of K were given to each animal with the K$^{42}$ for the two experiments, respectively. All cows were maintained on an 18% protein concentrate with alfalfa hay as the only roughage and were kept in elevated digestion stalls for a four-day preliminary and a nine-day experi-

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mental period. Daily total weights of urine and feces were taken separately and milk weights were taken twice daily. Samples were taken for analyses at the time of weighing. Blood samples were collected daily from the jugular vein. The amount of isotope in the blood was calculated on the basis of blood being 7.7% of the animal's weight. Aliquots of all samples were placed in glass tubes directly and counted in a well-type scintillation counter. The Cs\(^{134}\) and K\(^{42}\) counts were separated by making an initial total count and a subsequent Cs\(^{134}\) count after the K\(^{42}\) had decayed.

RESULTS AND DISCUSSION

During these experiments, the average daily hay and grain consumption were 4.44 ± 0.99 kg. (9.8 ± 2.2 lb.) and 5.34 ± 0.34 kg. (11.7 ± 0.7 lb.), respectively. Feed consumption was approximately the same for the two experimental periods. The average milk production for the eight cows for 210 hr. was 7.94 ± 2.98 kg. (17.5 ± 6.6 lb.), urine excretion was 8.75 ± 1.78 kg., and feces elimination was 14.18 ± 2.63 kg. per day.

The cumulative Cs\(^{134}\) and K\(^{42}\) excretion patterns in milk, urine, and feces are presented in Figures 1, 2, and 3. The data from eight animals were averaged to obtain these curves.

Total excretion of Cs\(^{134}\) for the eight cows in milk, urine, and feces averaged 73.3 ± 6.6% of the administered dose for the 210-hr. period.

Observed ratios of Cs\(^{134}/K^{42}\) are presented in Table 1 for each of eight cows. The observed ratio is a method of expressing the change in the fraction of Cs\(^{134}/K^{42}\) from the diet to blood, urine, or feces or from one animal compartment or system to another. All ratios reported in Table 1 were determined from the cumulative excretion of Cs\(^{134}\) and K\(^{42}\) over the 66-hr. period. Ratios

![Figure 1](image)

**Fig. 1.** Cs\(^{134}\) and K\(^{42}\) secretion in milk (average cumulative excretion of eight cows).
greater than one indicate a more favorable passage of Cs$^{134}$ than of K$^{42}$, whereas ratios less than one indicate a more favorable passage of K$^{42}$ than of Cs$^{134}$.

The action of cesium versus potassium is not fully understood. Relman et al. (7) in 1957 found that cesium would replace rubidium which, in turn, would replace potassium in muscle cells. Essentially, the membranes in mammary
CESIUM AND POTASSIUM IN COWS

TABLE 1

<table>
<thead>
<tr>
<th>Cow</th>
<th>Blood/diet</th>
<th>Urine/diet</th>
<th>Milk/diet</th>
<th>Milk/blood</th>
<th>Urine/blood</th>
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<tr>
<td>1</td>
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<td>.50</td>
<td>1.60</td>
<td>1.78</td>
<td>.56</td>
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</table>

<sup>a</sup> Observed ratio (sample-precursor) = \( \frac{\text{Cs}^{134}/\text{K}^{42} \text{ of sample}}{\text{Cs}^{137}/\text{K}^{42} \text{ of precursor}} \)

<sup>b</sup> Calculated from cumulative totals for a 66-hr. period.

Cesium and potassium are concentration membranes; therefore, the findings reported in this paper agree with those of Relman et al.

Previous work of Hood and Comar (2) indicate that a cow given an oral dose of Cs<sup>137</sup> excreted 9.6, 30, and 40% in milk, urine and feces, respectively, in 30 days. The findings in the experiments reported here are compatible with the earlier work.

Mraz and Patrick (6) reported that dietary potassium increased the rate of excretion of body cesium in the rat. Mraz (4) reported in 1959 that dietary potassium significantly increased excretion of both K<sup>42</sup> and Cs<sup>134</sup> in sheep, both in the presence and in the absence of dietary sodium. It has also been reported by Mraz and Patrick (5) that feed ingredients such as oat hulls, wheat bran, alfalfa meal, and crude soybean oil meal influence the excretory pattern of Cs<sup>134</sup> and K<sup>42</sup> in rats by increasing the excretion of these nuclides in the feces. This appeared to be an adsorption phenomenon.

The two groups of animals were, therefore, maintained on the same diet; however, certain differences in response were noted between the two experiments. An average of 9.48 kg. of urine was excreted per day from cows in the October experiment, whereas 7.00 kg. of urine was excreted per day in January. The Cs<sup>134</sup> and K<sup>42</sup> excretions were 16.8 and 44.6%, respectively, in October, and 21.2 and 31.1%, respectively, in January.

The blood and plasma values of Cs<sup>134</sup> and K<sup>42</sup> for each of the experimental periods are supporting evidence for a changing differential cesium and potassium excretion by way of the kidney. These data are presented in Figure 4. In the October experiment it was evident that K<sup>42</sup> was cleared relatively rapidly from blood and plasma; whereas in the January experiment, blood and plasma were still undergoing an accumulation up to 42 hr. It is also evident that cesium was more rapidly cleared from blood and plasma in the January experiment.

The main difference between the two experiments appeared to be environmental temperature. Average high and low atmospheric temperatures during the October period were 68.7 and 43.3° and during the January period were 52.9 and 30.7° F. Exact barn temperatures are not available, but would have
been considerably influenced by these differences. It is thought that the higher temperatures would coincide with higher glucocorticoid secretion which, in turn, would cause xaluresis and may inhibit the antidiuretic hormone with resulting diuresis (3). This is speculative and we have made no specific measurements of glucocorticoids.

![Graph showing concentration of Cs and K in blood and plasma at 18 and 42 hr. after oral administration.](image)

**Fig. 4.** Concentration of Cs and K in blood and plasma at 18 and 42 hr. post-dosing.

Milk production for the two experiments was different (averages of 10.1 and 6.3 kg, or 22.2 and 13.9 lb. per day), with an average per cent of secretion per liter of 0.312 and 0.279 of cesium and 0.179 and 0.202 of potassium in 66 hr. for October and January, respectively.

**REFERENCES**


