TRANSFER OF IODINE-131 FROM DEPOSITION-TO-MILK : ESTIMATION OF PASTURE INTAKE

M. Dreicer[1], A. Bouville[2], and B.W. Wachholz[2]
1 Lawrence Livermore National Laboratory, Livermore, California USA
2 National Cancer Institute, Bethesda, Maryland USA

For most individuals, milk consumption is the most important environmental pathway for the transfer of Iodine-131 from fallout to humans (Eisenbud and Wrenn 1963, Garner and Russell 1966). In assessments of radiological transport of I-131 from fallout deposition to cow's milk, knowledge of the fraction of the dairy cow's diet that is due to fresh pasture is essential because it is the only portion of the feed that may be contaminated to a substantial extent. For studies involving past fallout events covering large geographic areas, such as the current effort by the National Cancer Institute to assess the exposure to I-131 received by the American people during the Nevada Test Site atmospheric weapons tests conducted during the 1950's, it is necessary to derive this estimate of pasture consumption from past records. These estimates will be utilized in a model described in a companion paper presented in this symposium (Bouville et al. 1988).

Information on current pasture feeding practices cannot be used for the 1950's because the trend toward larger farms and greater daily food intake requirements by high milk producing cows has greatly diminished the use of pasture feeding on dairy farms (McCullough 1981). Today, in many cases, pasture feeding has been replaced by drylot feeding (Ward and Whicker 1987), which utilizes little or no pasture grazing.

In the United States, the only nationwide standardized information source for data on the diet fed to dairy cows is provided by the Dairy Herd Improvement Association (DHIA). Farmers participating in this program report the weight of the cows, the milk production, the fat content in the milk, the amount of concentrates, succulent and dry forages fed to the cows, and the number of days the cows were put on pasture to graze. The DHIA summarizes the data in yearly herd averages and calculates both the estimated net energy in the diet from the different feeds and the ratio of the amount of energy fed to the amount required by the cows. The yearly herd averages, starting in 1953 for most states, have been stored in computer form.

From these data, the average daily total net energy intake by cows can be calculated and the fraction of the energy intake that is from pasture can be then converted to mass of pasture consumed per day. In order to be consistent with data values derived by the DHIA during the 1950's and 1960's, the methodology presented uses the same assumptions and relationships that were used at that time (Wadell 1986 pers. comm.). Current methods employ slightly different assumptions. Therefore, the results calculated using today's methods (NRC 1978; McCullough 1981; Etgen and Reaves 1978) would be slightly different from those presented here. The steps of the calculation are shown in equations 1-6, below.

The net energy intake, NE (Mcal), needed by lactating cows is the sum of the net energies needed for maintenance of the body, NE_m, and milk production, NE_p:

$$NE = NE_m + NE_p. \quad (1)$$

The net energy needed by lactating cows for maintenance of the body is a function of the average body weight, BWT, of the cow:

$$NE_m = [0.012 \times BWT] + 0.83, \qquad (2)$$

where NE_m is expressed in Mcal and BWT in kg. The net energy needed to produce milk, Mcal, depends on the percentage of fat in the milk, FATPC, and on the daily milk yield, MY, in kg. It is calculated by:

$$NE_p = [(0.09 \times FATPC) + 0.35] \times MY. \qquad (3)$$

The daily milk yield is determined by dividing the reported total yearly milk production by the number of days in the year.

The actual amount of energy fed to the cow is usually greater than the calculated net energy intake requirement, in order to account for the additional energy expended during the normal activity of the animal. The feed index, FI, defined by the DHIA as the ratio of energy that is actually fed to the cow to the calculated requirement, ranges from 1.05 to 1.15 in the Northeast and is used to estimate the total net energy fed, NE_{fed} (Mcal), to the cow:

$$NE_{fed} = NE \times FI. \qquad (4)$$

The yearly aver$e of the daily pasture intake, PI_y, in kg (dry matter), is estimated as:

$$PI_y = [NE_{fed} \times NEPAST] \times CF, \qquad (5)$$

where NEPAST is an estimate of the fraction of the cow's net energy intake that is from pasture in a given year, and CF is a conversion factor from Mcal to kg (dry matter). For the purpose of this study, an average value of 1.47 Mcal kg^{-1} has been adopted for CF on the basis of the relevant data for the major pasture types (NRC 1978).

The annual averages of pasture intake, for each of the northeastern states, were calculated using the method described above with the computerized data available from 1953 to 1964. The results showed a significant increase in pasture intake after 1958. It is unlikely that the pasture portion of the diet increased during the late 1950's because the use of pasture feeding was declining during that time (Ward and Whicker 1987). However, it has been speculated that this increase could be due to changes in data collection or tabulation that may have occurred when the DHIA records were computerized in 1959 (Wadell 1986 pers.comm.). Since it is unknown if the estimates reported before or after 1958 are more representative, the average and standard deviation of the complete data set are being used.

Using the 26,800 records available for the state of Pennsylvania, from 1953 to 1964, as an example, it was found that the average DHIA cow weighed 683 kg and produced about 15 kg of 4.0% butterfat milk per day. Virtually all of the farmers reporting to the DHIA put their cows out to pasture during the year. The total daily net energy intake averaged over the whole year, NE_{fed}, was calculated as 19.1 Mcal d^{-1}; the value of NEPAST,the net energy from pasture, was 14.9%. Converting the net energy intake to mass of intake, it was found that the daily total dry matter intake was 13.4 kg d^{-1}, including the daily pasture intake averaged over a year, PI_y, of about 2 kg d^{-1}. The total dry matter intake, 13.4 kg d^{-1} falls within the 10 to 20 kg d^{-1} range of reported values for dry matter intake of dairy cows (Morrison 1961; Koranda 1965; NRC 1978; CES 1979; Ward and Whicker 1987; Leaver 1985).

The pasture intake usually occurred only during a defined pasture season each year so the length of the pasture season must be used to estimate the average daily intake during the time of grazing. The pasture season length was estimated, in each state, from the reported DHIA values, USDA Extension Dairy Specialists advice, and other sources. The average daily pasture intake during the pasture season, PI_s, in kg, is calculated by:

$$PI_s = PI_y \times (DY/PD), \qquad (6)$$

where DY is the number of days in a year and PD is the number of pasture days.

Daily intake of pasture is not constant during the pasture season. Information on the monthly variations of feeding practices in each state was also obtained from the USDA Extension Dairy Specialists. The preliminary estimates of daily pasture intake by month for Pennsylvania are shown in Fig. 1. As is illustrated, the cows were out on pasture by the beginning of May through most of October, for an estimated 176 days. The peak pasture season occurs during the spring and early summer, and pasture intake drops during the heat of the summer as a result of the decrease in pasture quality. During the peak of the pasture season in Pennsylvania, the pasture intake is estimated to be about 50% of the cow's total dry matter intake or about 7 kg d^{-1}.

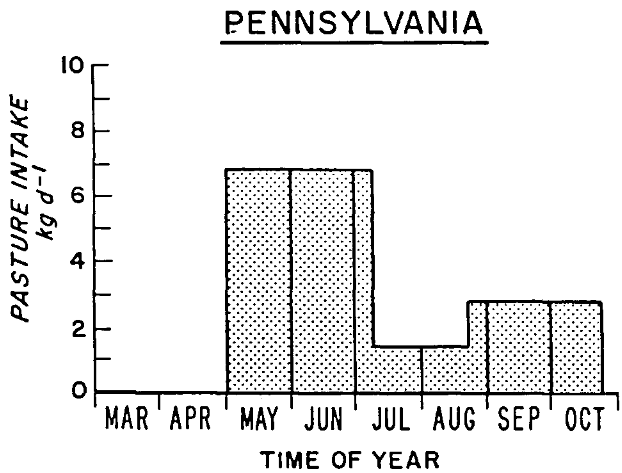

Figure 1. Preliminary estimates of pasture intake of dairy cows in Pennsylvania, USA during the 1950's and early 1960's.

Unfortunately, the percentage of net energy from pasture is no longer reported by the DHIA, so a direct comparison cannot be made between past and present pasture practices. A decrease in pasture utilization is however apparent from the number of farmers using dry lot feeding and the shorter pasture season reported by the farmers that put their cows on pasture. Virtually all of the farmers during the 1950's and 1960's reported some pasture feeding, but only about 75 percent of the 6100 records collected in Pennsylvania during 1985 reported days on pasture for their herds. For these farmers, the pasture season averaged 107 days a year, which is about two months shorter than the average value reported for the 1950's.

Total dry matter intake also varied between past and present practices. For example, in Pennsylvania during 1985, the average DHIA cow was smaller (544 kg vs 683 kg) and produced more milk per day (23.4 kg vs 15 kg), with a lower butterfat content (3.7% vs 4.0%), than a cow 2 to 3 decades earlier. Using current methods of calculation (NRC 1978) and the 1985 average values presented above, an estimate of the total daily dry matter intake of 15.8 kg d^{-1} is calculated. This shows that even though pasture intake may be providing a smaller part of the total diet of dairy cows today, the total daily intake has increased.

Acknowledgements - The authors would like to thank: H.L.Beck, Environmental Measurements Laboratory; J.Till, Radiation Assessments Corporation; G.Ward, F.W.Whicker, Colorado State University; L.Wadell, Cornell University; G.Wiggans, C.Ernst, Animal Improvement Programs Laboratory, Maryland; K.Butcher, G.Griffin, North Carolina State University.

REFERENCES

Bouville, A.; Dreicer, M.; Beck, H. L.; Wachholz, B. W. Assessment of Iodine-131 Transfer to Cows milk Resulting from the Nevada Weapons Tests of the 1950's. in press (this volume); 1988.

CES: Cooperative Extension Service. College Conference: Dairy feeding programs New England [Available from College of Agriculture and Natural Resources, The University of Connecticut Storrs, CT 06268]; 1979.

Eisenbud, M.; Wrenn, M. E. Biological disposition of radioiodine - A review. Health Phys. 9:1133-1139; 1963.

Etgen, W. M.; Reaves, P. M. Dairy cattle feeding and management. 6th ed. New York: John Wiley and Sons, Inc.; 1978.

Garner, R. J.; Russell, R. S. Isotopes of iodine. In: Russell, R. S., ed. Radioactivity and human diet. New York: Pergamon Press L.; 1966; pg:297-315.

Koranda, J. J. Agricultural factors affecting the daily intake of fresh fallout by dairy cows. Livermore, CA: Lawrence Livermore National Laboratory; UCRL-12479; 1965.

Leaver, J. D. Milk production from grazed temperate grassland. J. Dairy Res. 52:313-344; 1985.

McCullough, M. E. Optimum feeding of dairy animals for milk and meat. Athens, GA: University of Georgia Press; 1981.

Morrison, F. B. Feeds and feeding. Abridged 9th edition. Ontario, Canada: The Morrison Publishing Company; 1961.

NRC: National Research Council. Nutrient requirements of dairy cattle. 5th revised ed., Washington, DC: National Academic Press; 1978.

Wadell, L. Dairy Records Processing Laboratory Cornell University Department of Animal Sciences, Ithaca, New York 14853-4801; personal communication; 1986.

Ward, G. M.; Whicker, F. W. Milk production and distribution in nine western states in the 1950s. UCRL-15907 NVO-312; March 1987. [Available from Technical information Department, Lawrence Livermore National Laboratory, University of California, Livermore, CA 94550.]