EXCRETION OF ORGANIC AND INORGANIC TRITIATED COMPOUNDS IN COW'S MILK AFTER INGESTION OF TRITIUM OXIDE.

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INTRODUCTION

The evaluation of the transfer of tritium in the environment is complicated by the fact that tritium can be incorporated into a variety of organic molecules whose metabolic behavior may differ greatly from that of tritium oxide (2, 3, 6, 7). An important link in the transfer of tritium to man is the secretion of tritiated molecules in milk (4, 5, 8, 10) because this has its impact on infants, the most sensitive part of the population. The secretion in milk of tritium as water and organic molecules (casein and lipids) was, therefore, studied after giving cows tritiated water to drink for a period of 25 days.

MATERIALS AND METHODS

Two lactating cows (weighing about 560 kg) were given drinking water containing 18.9 mCi/l tritium oxide for a period of 25 days (a tritium intake of 871.3 μCi/day, all values given being the means for both cows). The diet consisted of a hay supplemented with a concentrate consumption of food and water (46.6 l/day) as well as production of milk (20.8 l/day), urine (21.9 l/day) and faeces (32 kg/day) were determined daily. Radioactivity in water, dry matter, lactose, lipids and casein of milk was determined during this "loading" period and during a "decay period" of 75 days after application had been terminated. The different constituents were isolated as follows : milk water by scintillation, whole dry matter by lyophilization, lactose by cristallisation in ethanol, casein by precipitation with acid and fats by the Rose-Gottlieb procedure. The radioactivity was determined by liquid scintillation counting after the material had been combusted, except for water and fats which were counted directly. The data were fitted to appropriate functions for the loading and decay period using a nonlinear regression procedure. The calculations were carried out separately for turnover rates and turnover times to obtain standard errors directly. Statistical weighing according to a Poisson distribution was required for the data of the decay period to obtain the second exponential term. No such weighing was needed for the loading period since the range of the activities measured is relatively small. Analysis of variance indicated a good fit for all functions shown. The loading phase is best described by a single term integrated exponential function with a time delay.

$$A = A^{\infty} \left[1 - e^{-\alpha[t - T_d]}\right]$$

where A^{∞} the activity reached after very long times of application, α the turnover rate ($days^{-1}$) and T_d the time delay (days).
The behavior during the decay period can be approached by a two term exponential function :

$$A = A_1 e^{-\alpha_1 t} + A_2 e^{-\alpha_2 t}$$

where A_1 and A_2 the fractions of activity for each turnover component and α_1 and α_2 the respective turnover rates. The formulas for turnover times T (days) are obtained by replacing α with t.

RESULTS

Table 1 presents the parameters and their standard errors for tritium oxide, casein and lipid during the loading period. One recognizes that secretion starts after a short (0.5 day), but significant

Table 1: Parameters ± S.E. for "Loading phase" $\left[A = A^{\infty}\left[1 - e^{-\alpha\left[t - Td\right]}\right.\right.$

Compound	A^{∞} [pCi / g]	α [$days^{-1}$]	T delay [days]	$T\sigma$ [turnover time] [days]
Water	15 680 ± 49	0.2095 ± 0.00397	0.624 ± 0.057	4.773 ± 0.0904
Lipids	5865 ± 41	0.1478 ± 0.0049	1.08 ± 0.11	6.764 ± 0.225
Casein	2927 ± 25	0.1756 ± 0.0728	0.545 ± 0.105	5.68 ± 0.496

delay; for lipids this delay is about one day. Turnover of all three compounds is short, corresponding to an half life time of about 5 days; it is somewhat longer for lipids than for tritium oxide or casein. No second component can be distinguished during this phase but this is expected since the statistical variability exceeds by far the contribution of such a small fraction. The half life found appears relatively short if compared to that of other nonlactating great mammals (1, 5, 8), but is readily explained by the large water turnover of lactating cows. From the known specific activity of the drinking water and the tritium content of lipid and casein (11% and 7.6% respectively), one can calculate the dilution of the ingested water during metabolism. Thus about 83% of the milk water secreted is found to originate from

drinking water; the rest comes from water in food and from that formed in metabolism. About 38% of the hydrogen in dry matter, 30% of that in lipids, 48% of that in lactose and 22% of that in casein are derived from ingested water or from labeled recycling organic molecules. These values are compatible with observations by others (2, 6, 7).

The parameters of the decay phase presented in table 2 indicate that the principal components of water, casein and lipids have about

Table 2: Parameters ± S.E. for "decay phase" $\left[A = A_1 e^{-\alpha_1 t} + A_2 e^{-\alpha_2 t}\right]$

Compound	A_1 [pCi / g]	A_2 [pCi / g]	Time constants		Turnover times	
			α_1 [days^{-1}]	α_2 [days^{-1}]	T_0^1 [days]	T_0^2 [days]
Water	16 539 ± 50	7.41 ± 2.15	0.2073 ± 0.00047	0.0172 ± 0.00525	4.822 ± 0.011	58.2 ± 17.8
Lipids	6845 ± 105	26.6 ± 7.11	0.1834 ± 0.0026	0.00335 ± .00469	5.451 ± 0.071	29,9 ± 418
Casein	2994 ± 41	246 ± 47	0.1889 ± 0.0045	0.0413 ± 0.0056	5.29 ± 0.12	24.2 ± 33

the same turnover rates as during the loading phase. In addition, small fractions (about 0.04% for tritium oxide, 0.4% for lipids and 8% for casein) display much longer half lifes. The half life seems longest for lipids, but its is error marge. It should be noted that the fractions A_1 and A_2 presented in table 2 are those appearing after a loading period of 25 days; the long lived component would be much less important after a single application (table 3).

The data shown allow to calculate how much activity of each compounds and each metabolic component would be excreted after a single and after a continuous application of tritium oxide when integrated over infinite times (table 3). One recognizes that after single application tritium is mainly excreted as tritium water of rapid turnover, organic molecules participate only to about 3.9% and all slow metabolic components represent together about 0.2% of the total activity excreted. It should be noted, however, that when the milk is ingested by man the organic molecules may give rise to a much higher fraction of tritiated molecules with long life span than does tritium water. After continuous application, molecules with long half life, particularly lipids become more important and may represent somewhat more than 4% of the total; the values for lipids remain, however, subject to a rather large error and require further study.

	Fraction (pCi / g or %)		(% of total) Unique application		Continuous application	
	Rapid Component	Slow Component	Rapid Component	Slow Component	Rapid Component	Slow Component
Water	$2.92.10^6$	11.4				
%	96.7 %	$3.97.10^{-4}$ %	96	0.0045	92.3	0.052
Lipids	67083	28.9				
%	2.2 %	$9.57.10^{-4}$ %	2.49	0.058	2.71	3.48
Casein	32918	691				
%	1.09 %	$2.38.10^{-4}$ %	1.19	0.114	0.85	0.55

Table 3 - Metabolic components after single application and integrated activities after single and continuous application.

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