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NOTES

Uptake and Retention of Zinc-65 from Certain Foods*

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REPOSITORY PNL
COLLECTION 65 Zinc
BOX No. Soldat J
FOLDER 2/A

Introduction

ZINC-65 is one of the radionuclides formed by neutron activation in the cooling water circulated through the Hanford reactors. The 245-day half-life of this nuclide is long enough for it to persist in the river all the way to the coast and to enter the food chain of shellfish and other sea organisms which concentrate zinc.

An experiment was conducted in which one of the authors ate fresh oysters collected from the Washington coast, and his uptake and retention of ^{65}Zn from the oysters determined by whole-body counting. The oysters were analyzed for ^{65}Zn before consumption, permitting quantitative evaluation of the appropriate metabolic parameters.

The results indicate an average fractional zinc absorption of 13.5 per cent for this individual. The ^{65}Zn persisted in his body with an effective half-life (including both biological elimination and radioactive decay) of about 100 days. The highest body burden of ^{65}Zn attained during the course of this experiment was 40 nCi and occurred after eighty-one meals of oysters eaten in a period of 570 days. This may be compared with the recommendation of the International Commission on Radiological Protection that the sustained (lifetime) body burden of an individual should not exceed 6000 nCi of ^{65}Zn.

Experimental design

The experiment was designed to evaluate the uptake and retention of ^{65}Zn from the consumption of oysters collected on the Washington coast. The oysters were furnished by a commercial fishery and were analyzed by gamma spectrometry before being eaten. The ^{65}Zn content of the entire oyster meal was determined in this way to avoid the uncertainties of sampling. The analyses were performed in the radiochemical laboratory of the Washington State Department of Health. The oysters were eaten by one of the authors (P. W. HILDEBRANDT) who was given whole-body counts at irregular intervals to follow the buildup of ^{65}Zn in his body. P. W. H. lives in Seattle and was believed to have little opportunity of acquiring ^{65}Zn from a source other than the oysters.

Figure 1 shows the course of the experiment. The first oyster meal was eaten in October, 1963 but previous to that date, P. W. H. had been counted in the Hanford whole-body counter to establish an initial background count. During the next 20 months he ate eighty-one meals of oysters, an average of about one meal per week. As is evident from Fig. 1, the meals were not uniformly distributed during that time. There was one period of more than 5 months during which fresh oysters were not available and none were eaten. As P. W. H. lives some distance away, he could only be counted in the whole-body counter when visiting in Richland where the counter is installed. A total of 13 whole-body counts were made during the course of the experiment.

The whole-body counter used to observe the buildup of ^{65}Zn utilizes a $9\frac{3}{8}$ in. × 4 in. sodium iodide crystal activated with thallium, in a room shielded with 26 cm of iron.[1] A counting time of 20 min per measurement permitted an accuracy of ±5 per cent and a lower detection limit of approximately 1 nCi in the whole body.

The total ^{65}Zn ingested by P. W. H. during 20 months was 709 nCi included in 17,430 g of oysters. Thus, he ate an average of 215 g of oysters at each meal and the oysters averaged 41 pCi/g. The amount of ^{65}Zn transported by the Columbia River during the period of the experiment is shown in Fig. 2. A seasonal fluctuation resulting from sedimentation processes is clearly evident, the ^{65}Zn load varying from about 25 to more than 150 Ci/day. On the same chart is shown the concentration of ^{65}Zn in the oysters used in this experiment and which were collected near the mouth of the Columbia. The concentrations shown range between 20 and 60 pCi/g. As one might expect, the retention time of ^{65}Zn by oysters is long enough to mask seasonal fluctuations or correlations with the ^{65}Zn burden of the river.

Experimental results

The maximum ^{65}Zn body burden attained by P. W. H. was 40 nCi. The amount of radioactive zinc present in the body as a result of ingesting ^{65}Zn is a function of the fraction of dietary zinc absorbed and

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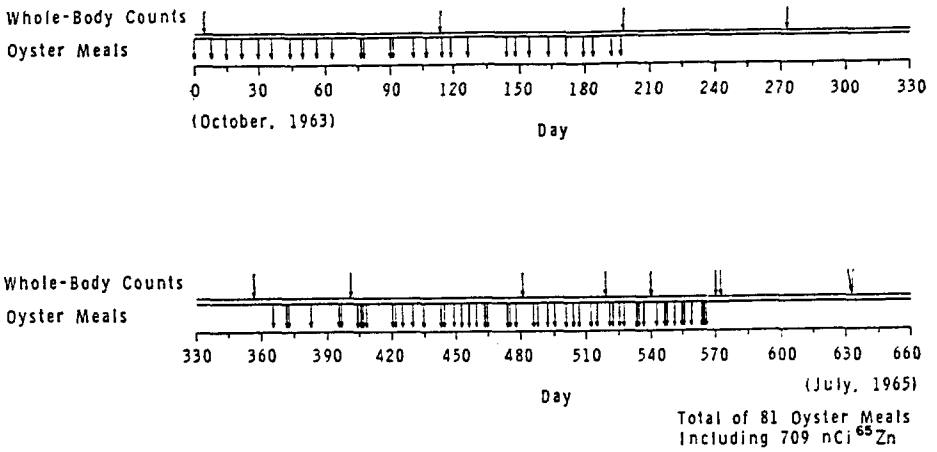

FIG. 1. The chronology of oyster consumption and whole-body counts during this experiment.

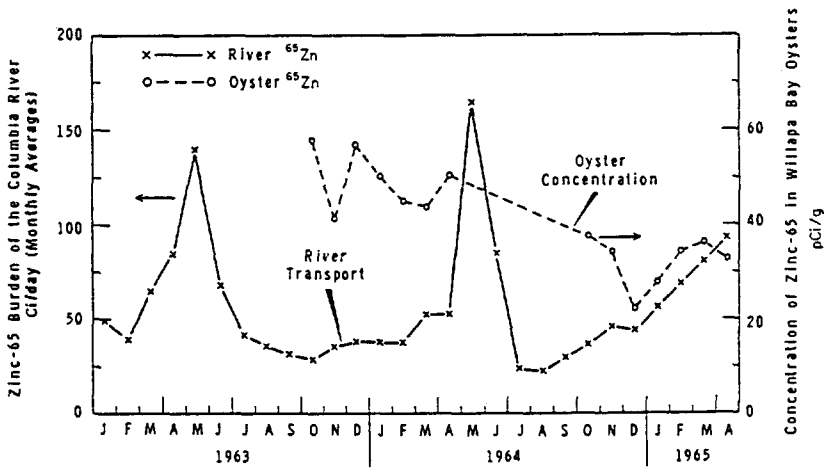

FIG. 2. A chart of ^{65}Zn transported to the Pacific Ocean daily during the period of this experiment. The observed concentrations of ^{65}Zn in Pacific oysters during the period are also shown.

the rate of turnover of zinc in the body. The values for this parameters used by the International Commission on Radiological Protection for calculating acceptable drinking water levels are 10 per cent absorption and an effective whole-body half-life of 194 days (including biological elimination and radioactive decay). These are quoted for a "standard man"; individual values may differ markedly from this average. The best fit values obtained for our experimental data for the case of ^{65}Zn from oysters were 13.5 per cent absorption and 100 days effective half-life.

The whole-body counting data obtained during the course of this experiment are shown in Fig. 3. The solid line is the calculated body burden using a fractional absorption (F_w) of 0.135 and an effective half-life ($T_{1/2}$) of 100 days. The fit of the measured body burdens to this theoretical curve is fairly good except for the first two points. The initial high ^{65}Zn body burdens indicate that possibly P. W. H. had acquired ^{65}Zn from foods other than oysters during this period. While it is possible that he occasionally consumed some ^{65}Zn from other sources, the contribution must have been generally very small. During the period from day 199 to day 366 no oysters were consumed, and the whole-body counts were

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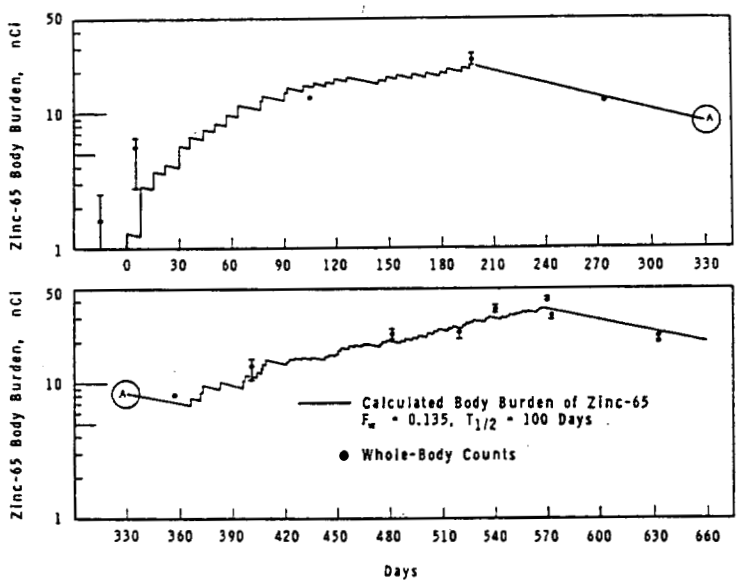

FIG. 3. The solid line is calculated ^{65}Zn body burden based on an assumed fractional absorption of 0.135 and an effective half-life of 100 days as a result of the oyster consumption shown in Fig. 1. The dots are ^{65}Zn body burden measurements in the Hanford whole-body counter.

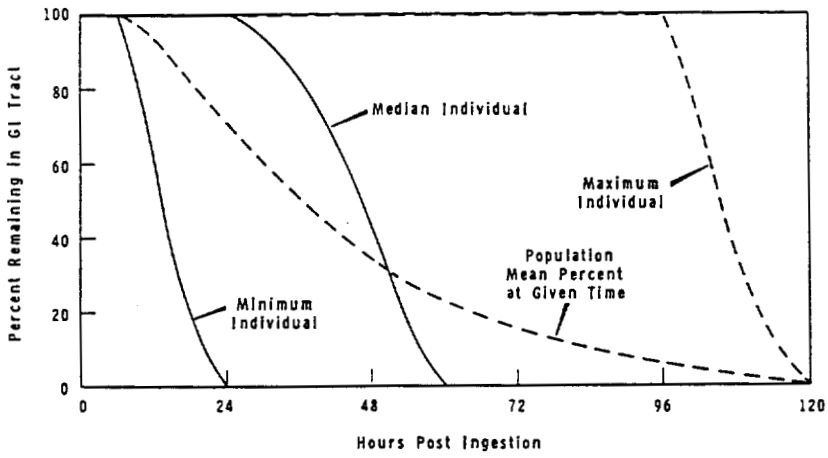

FIG. 4. The passage of insoluble material through the GI tract from the data of WALLACE *et al.*[2] The dotted curve was used to determine the analytical uncertainties shown as vertical bars through points in Fig. 3.

used to calculate an effective half-life for zinc in the body. The 102-day half-life obtained agrees well with the value of 98 days measured during the decay period at the end of the experiment. The apparent fractional uptake of ^{65}Zn from oysters ranged from 0.061 to 0.169 with an average of 0.135 and a standard deviation of 0.027.

The vertical bars on some of the points showing whole-body counts in Fig. 3 reflect an uncertainty resulting from the possible presence of unabsorbed ^{65}Zn in the GI tract contents. The data reported by WALLACE[2] on the passage of barium sulfate through the digestive tract of fifty-five subjects were used to evaluate this uncertainty. The points evaluated were those made within 5 days after an oyster meal. The GI tract retention data are summarized in Fig. 4.

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The figure shows the GI tract passage curves for the minimum, median, and maximum individual examined by WALLACE. From these data we derived a population mean (dotted line) which was used to calculate the uncertainties shown in Fig. 3. The size of the bars reflects the amount of ^{65}Zn in the latest oyster meal and the length of time elapsed until the whole-body measurement.

Conclusions

The fractional absorption (13.5 per cent) and effective half-life (100 days) measured for ^{65}Zn from the consumption of Pacific oysters seems to be somewhat different from those values used by the ICRP (10 per cent and 194 days) for calculating permissible drinking water concentrations. However, the experimental results reported here are for a single subject and cannot be used to draw valid conclusions for a "standard man." Values different from these reported by the ICRP were also obtained in earlier experiments which determined the uptake and retention of ^{65}Zn from the consumption of Columbia River fish.[3,4] It was found that the average absorption of ^{65}Zn by seven subjects was 32 per cent and the effective half-life was 162 days. It is probable that the "specific activity" of ^{65}Zn (concentration of ^{65}Zn relative to that of stable zinc) in the flesh of aquatic organisms is actually lower than that in other foods and is responsible for the high turnover rate obtained for zinc from these sources. There is some evidence that zinc is absorbed more readily from such foods than from drinking water. This might reflect some differences in chemical form, but more probably simply indicates individual differences in the metabolisms of the subjects studied.

The accumulation of ^{65}Zn from a very heavy consumption of Pacific oysters resulted in a body burden of only 40 nCi. This may be compared with the maximum permissible body burden recommended by the ICRP of 6000 nCi, based on an assumed lifetime sustained level and for members of the public living in the neighborhood of controlled areas. The ICRP-recommended maximum body burden for occupational exposure is even greater, being ten times that for members of the public. P. W. H. averaged about one meal of oysters per week. To have maintained a body burden equal to the limit recommended by the ICRP would have required him to eat an average of 150 meals of oysters a week. The likelihood of any individual eating more than 70 lb of oysters a week seems small. The results of this experiment thus support the conclusion previously derived from the Hanford environmental evaluation program that the ^{65}Zn in Pacific oysters does not contribute significantly to the radiation exposure of members of the public.

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