LIST OF PUBLICATIONS

Trace Element Concentration in Human Hair.
A Study by Instrumental Neutron Activation
(India) 21 B.

Trace Elements in Animal Feed and Animal Tissues: A
Correlation Study by Neutron Activation Method.

Mechanical Properties of Human Hair and the
Effect of Chemical Treatment - Bleaching and
Dyeing. Res. Bull. Sci. Panjab University,
32: 77 - 88.

Biokinetics of Sodium selenite in Subcellular
Fractions of Rat Organs. Proceedings of the
XIVth Annual Conference of the Society of Nuclear
Medicine, Chandigarh, India, November, 1982.

Biokinetics of $^{75}$Se (Selenite) in normal
and tumor-bearing mice. Proceedings of the
VIIth International Congress of Radiation Research,
Amsterdam, Netherlands.

Trace Elements in Normal and Tumor-bearing Mouse
Organs - A study by Neutron Activation Method.
Proceedings of Xth Indian Biophysics Symposium,
Hyderabad, India.

DNA Activity in Mouse Organs in Chemical
Carcinogenesis and its Modification by Sodium
Selenite. Proceedings of the XIIth IRS Symposium
on Structure, Assembly and Functions of
Biomolecules, Mysore, India.
Trace Elements in Animal Feed & Animal Tissues: A Correlation Study by Neutron Activation Method

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Concentrations of 12 trace elements have been determined in the Hindustan Lever rat and mice feed by neutron activation method without chemical separation, employing a 64 cc Ge(Li) detector and a 4096 channel pulse height analyser. These concentrations are Fe (386±43), Zn (1£±0.6), Cr (1.05±0.34), Co (0.256±0.005), Se (0.156±0.027), Rb (3.16±0.18), Sb (0.014±0.008), Sc (0.410±0.028), Hg (0.129±0.053), Eu (0.165±0.006), Cs (0.935±0.067) and Hf (0.037±0.011) μg per g of dry weight. These concentrations have been compared with the concentrations of these elements in tissues of the rats kept on this feed. The concentrations of essential trace element, viz. Fe, Zn, Co and Se in the feed and the rat tissues have been found to be comparable in magnitude. Cr, though an essential element, is found at a lower level in rat tissues as compared to that in feed. The non-essential trace elements namely Rb, Sc, Hg, Eu and Hf, detected in the animal feed, except Sb, are either totally absent or much lower in concentrations in the rat tissues. This indicates that non-essential trace elements are poorly absorbed by the animal system as compared to the essential trace elements.

Trace element analysis of rat and mice feed of Hindustan Lever Pvt Ltd, Bombay, has been carried out by neutron activation method without chemical separation, employing a 64 cc Ge(Li) detector coupled to a 4096 channel pulse height analyser. This type of feed has been in constant use in our laboratory for experimental animals since long time but concentrations of various trace elements present in this feed were not known. A prior information about the concentrations of various trace elements in the animal feed is essential for experiments, being conducted in this laboratory, to understand the role of trace elements in health and disease. Therefore, this analysis has been undertaken. In this study 12 trace elements namely Fe, Co, Zn, Se, Cr, Sc, Rb, Sb, Cs, Hg, Eu and Hf have been detected in the feed samples. The concentrations of these trace elements and their correlation with the level of their concentrations in rat tissues, already studied in this laboratory, are given in the text.

Materials and Methods

Samples of Hind-Lever rat and mice feed were taken randomly. These samples, weighing 800 mg - 1 g, were wrapped in aluminium foils and irradiated for a week in CIRUS reactor at Bhabha Atomic Research Centre, Trombay, Bombay under a neutron flux of 5 x 10¹² neutrons per cm² per sec. Because of the high activity of 24Na and 42K build up in the samples, a decay time of 28 days was given after irradiation. During this period all the short lived isotopes decayed to a very low level of activity. The samples were then removed from the wrappers and sealed in the properly washed polythene bags. Gamma-ray spectra of the irradiated samples were taken with a 64 cc Ge(Li) detector coupled to a 4096 channel pulse height analyser. The energy resolution of the γ-ray spectrometer was 2.1 KeV for 1333 KeV γ-ray of 60Co, and its relative efficiency was 11%.

Three mixed standards containing 7 elements namely Cr, Co, Zn, Fe, Se, Rb and Hg, were made with cellulose as base. These standards and a blank cellulose tablets were irradiated along with the samples under exactly similar conditions. The concentrations of Cr, Co, Zn, Fe, Se, Hg and Rb in the feed samples are computed with reference to the added standards whereas the concentrations of Sc, Sb, Cs, Eu and Hf are determined by the internal standard method.

Results and Discussion

A typical γ-ray spectrum of an irradiated feed sample is shown in Fig. 1. The γ-ray spectra are taken by placing the samples, one by one, on the axis of the detector at a distance of 4 cm from the face of the detector. An aluminium foil of thickness 2.5 mm was placed in between the sample and the detector to reduce bremsstrahlung. The concentrations of the various trace elements have been computed by taking the areas of the distinct and most intense photopeaks of the respective isotopes. In case of 203Hg, photopeak at 279 KeV is getting contribution from 75Se. Therefore, the concentration of Hg is calculated by subtracting the contribution of 75Se in this peak area. A photopeak of 344 KeV is a composit peak having contributions from 175Hf, 152Eu and 181Hf radioisotopes. The three components of this peak are found to tally well with the areas computed with the help of the photopeaks of 181Hf and 152Eu at 482 and 441 KeV.
1407 KeV respectively and thereby confirm the presence of Hf and Eu detected in the animal feed. The photopeak at 603 KeV is a composit peak due to the presence of 603 KeV γ-ray of 134Cs and 605 KeV γ-ray of 124Sb. The contribution of 603 KeV γ-ray of 134Cs in the peak area has been computed by taking the 796 KeV γ-ray peak of 134Cs as reference. The remainder is attributed to the 605 KeV γ-ray of 124Sb. This gives the concentration of 124Sb as 0.014 ±0.008 µg/g of the dry weight. The presence of a photo-peak at 1694 KeV due to 124Sb confirms the presence of 124Sb in the feed samples. In all, 12 trace elements namely Fe, Zn, Co, Cr, Se, Sb, Rb, Sc, Cs, Eu, Hf and Hg are detected in the feed samples. The results of this analysis are summarized in Table 1. The concentrations of most of these elements in rat liver, kidney and testis, as found in our previous studies¹, are compared with those in the feed (Fig. 2).

It can be seen from Fig. 2 that the concentration of Fe in liver is higher by 17% whereas in kidney and testes, it is lower by a factor of 2.5 and 2.1 respectively as compared to that in the feed. The concentration of Zn is higher by 39% in liver and by a factor of 5.1 in testes. In kidney it is lower by 5.3% only. The concentration of Cr is lower by a factor of 3.7 in kidney and it is below detection limits in liver and testes, though present in the feed at a level of 1.05 ± 0.34 µg/g of dry wt. It appears that Cr is poorly taken up in animal organs. It is in agreement with the earlier reports in literature²,³. Co is found at a level lower by a factor of 2.3 and 8.8 in liver and testes respectively and it is lower in kidney by 10.9% only as compared to that in the feed. Se is lower by a factor of 3.6 and 2.9 in the liver and kidney respectively and higher by 18% in the testes as compared to that in the feed. Rb is lower in all the three tissues by a factor greater
than $10^3$ as compared to that in the feed. Sb is lower in liver and kidney by a factor of 7 and 5.6 respectively whereas in testes this element is found to be below detection limits. Ag was detected in all the three rat organs in our previous study$^1$, though found at sub-ppm level, but in the feed samples this element is found at a level below detection limits. Possibly this element enters the animal system as pollutant from environment other than the feed. Se is found at a much lower level of concentration in the animal organs as compared to that in the feed. The other 3 elements namely Hg, Eu and Hf detected in the animal feed are either absent or below detection limits in the three rat organs.

This analysis shows that the levels of concentrations of the essential trace elements namely Fe, Zn, Co and Se in rat organs are not much different from those in the animal feed except Cr. Cr is poorly taken up by the liver and testes. The concentrations of all the non-essential trace elements except that of Sb in rat organs is less by a factor greater than $10^3$. It clearly indicates that non-essential trace elements except Sb, though present in the animal feed at appreciably high level of

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<th>Table 1 — Concentrations of Trace Elements in Rat and Mice Feed Manufactured by Hindustan Level Pvt Ltd</th>
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<td>Element</td>
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concentrations are poorly accumulated by the animal organs as compared to the essential trace elements.

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References