APPLICATION OF PROMPT GAMMA ACTIVATION ANALYSIS AND NEUTRON ACTIVATION ANALYSIS TO THE USE OF SAMARIUM AS AN INTESTINAL MARKER

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The use of prompt gamma activation analysis (PGAA) as a method for detection of the intestinal rare earth marker, samarium, has been evaluated by comparison with thermal neutron activation analysis (NAA). PGAA detection has significant advantages with respect to its higher reaction cross section and possible rapid experimental turnaround time. Serious disadvantages are lower neutron fluxes available to the target and nonavailability of numerous PGAA facilities. Results of the technique comparisons are generally very good. Pony fecal concentrations of samarium in samples obtained at various times after administration of a marked meal were measured by both techniques. In only one sample did results of the methods differ by more than the experimental errors involved.

Introduction

The use of rare earth elements as intestinal markers in nutrition research has been vigorously studied for the last 30 years. As early as 1952, SCHWEITZER and JACKSON recognized that these elements exhibited strong adsorptive properties to gastrointestinal fill particulates and were themselves essentially inert to the digestion process. An extensive review by KOTB and LUCKEY in 1972 and a later work by MACRAE have emphasized the required characteristics for a material to be considered an effective marker. One qualification of importance is that the marker must be readily discernible from intestinal tract material by some precise, quantitative measurement. In many instances neutron activation analysis (NAA) has been used successfully to determine rare earth element concentrations in various intestinal samples resulting from doping of meals with stable element.

NAA has been shown to be an effective, sensitive method having significant advantages over many other techniques due to its multielement capabilities. Several rare earth elements, having a wide range of nuclear parameters, have been utilized as markers in NAA nutritional experiments. This allows for the tailoring of the experi-

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ment to the specific conditions desired in the study. Recently, variations of the technique have been evaluated. CERCASOV and HELLER\textsuperscript{8} applied fast (14 MeV) NAA to the determination of cerium and samarium in samples taken from the forestomach of llamas fed marked hay meals. This method requires an inherently less expensive determination and therefore has a distinct advantage over thermal NAA. This communication describes the analytical results of a nutritional study in which samarium was determined in pony fecal samples by both conventional thermal NAA and by another variation, prompt gamma activation analysis (PGAA).

The absorption of nutrients from the gastrointestinal tract is proportional to the length of time digesta resides within this system. The objective of the animal experiment was to measure the total tract retention time in ponies fed a mixture of oat groats, oat hulls, hay leaf, and hay stems. The total project involved the use of multiple rare earth markers in each of these feed components. However, for the purpose of illustrating the capabilities of PGAA, samarium alone has been determined by both methods.

### Prompt gamma activation analysis (PGAA)

PGAA is based on the detection and quantification of gamma rays emitted during de-excitation of the compound nucleus which has resulted from the neutron capture (n, y) reaction. Because these emissions are produced and counted during the irradiation, it is not important whether the reaction product exhibits any particular nuclear parameters such as half life. In fact the technique is very sensitive in the determination of some elements which have nuclides exhibiting extremely high capture cross sections yielding stable products. Examples of this include B-10 and Cd-113. Other advantages of the technique include absence of the requirement to perform decay corrections for radioactive products and quick turnaround times. Energies of the gamma emissions, as in conventional NAA, are characteristic of specific nuclear transformations and thus target nuclide.

<table>
<thead>
<tr>
<th>Nuclear reaction</th>
<th>Isotopic abundance, %</th>
<th>Cross section, barn</th>
<th>Neutron flux, ( n \cdot cm^{-2} \cdot s^{-1} )</th>
<th>Half-life</th>
<th>Technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sm-152(n, y)Sm-153</td>
<td>26.7</td>
<td>204</td>
<td>(~1 \times 10^{19})</td>
<td>46.5 h</td>
<td>NAA</td>
</tr>
<tr>
<td>Sm-149(n, y)Sm-150</td>
<td>13.8</td>
<td>42 000</td>
<td>(~5 \times 10^{7})</td>
<td>Stable</td>
<td>PGAA</td>
</tr>
</tbody>
</table>