In feedlot systems trace element supplementation can most easily be provided through dietary additives.

For treating animals under grazing systems, oral or parenteral doses which are many times the daily requirement are normally used. These treatments are time consuming to administer and are impracticable with animals handled infrequently. They also involve the risk of traumatic injury, inhalation pneumonia and, because high peak concentrations occur within the animal, toxicity.

Mineral licks or drinking water additives overcome some of these problems, but individual intakes are extremely variable and deficiencies or toxicities may still occur.

These problems could be avoided by the use of a depot of the trace element(s) at a site from which it is released at a relatively constant level of the element in body tissues.

For the provision of trace elements to sheep a number of sub-dermal implants and intra-ruminal devices have been developed. This article outlines the results of some studies to evaluate the efficacy of cobalt pellets, selenium pellets, soluble glass pellets (containing cobalt, selenium and copper), and copper oxide needles.

COBALT PELLETS

A method of treating cobalt deficiency in sheep has been devised using the tendency of heavy foreign bodies to remain within the ruminant fore-stomach.

Initially, mixtures of cobaltic oxide (75-95%) and china clay (5-25%) were pressure and heat moulded into pellets (density 3.5-4.1). Although these pellets were successful in some trials, the build-up of calcium phosphate was only partially effective. Heavier and denser pellets composed of 60% cobaltic oxide and 40% finely comminuted iron were then developed.

Results of a recent trial with one batch of these dense pellets showed an initial rapid and significant rise in serum vitamin B12, compared with values after injections of hydroxocobalamin or weekly drenching with either cobalt sulphate or chelated cobalt (EDTA)(13). However, after 14 weeks liver and serum vitamin B12 levels of pellets sheep were not significantly different from those of untreated sheep (Fig. 1). At this stage 25% of the sheep were shown by radiography to have lost their pellets.

Grinders were not used in this study as they are not permitted in New Zealand because of damage they cause to machinery in freezing works.

SOLUBLE GLASS

Soluble glasses(3) were designed to be implanted subcutaneously and to dissolve at a controlled rate under physiological conditions. The rate of dissolution can be altered substantially by small changes in the chemical composition of the glass(9,15).

Glasses containing selenium showed promise(2), but those containing copper which were required to dissolve at a faster rate, led to severe tissue reactions brought about by the toxic effect of localized high levels of copper(1).

To overcome this problem it was suggested that the glass could be implanted at a site with a more rapid flow of tissue fluids (e.g., intra-peritoneally). However it was considered that a more practical alternative would be soluble glass intra-ruminal pellet.

By kind permission of Professor A.D. Care we were given the opportunity to evaluate a batch of pellets designed to provide cobalt, selenium and copper to sheep. One group of 30 lambs at Wairakei was given the pellets in December 1983 and a further 10 lambs served as controls. Analytical results to date are given in Table 1.

As losses of the pellets have been high (14/30 in 6 months), values for the pelleted group have been included only from animals in which the presence of the pellet has been confirmed by radiography.

Because the glass pellets dissolve more rapidly than do selenium or cobalt pellets, coating should not pose a problem. Fragmentation of the pellet in the gut probably accounts for the losses and is a problem which needs to be overcome.

Copper oxide needles

Oral administration of copper oxide in particulate form to sheep is an effective method of copper supplementation(7). The high density (6.3) and low mass of these particles are such that they quickly leave the rumen, where copper can be rendered unavailable, and become lodged in the wall of the abomasum. A 2.5 g dose of copper oxide wire was more efficacious than diethylylamo cupro-oxyquinoline sulphonate (Cujec®) in improving the copper status of Merino waefer sheep(12).

Preliminary results of a current trial in which copper levels are being monitored in liver biopsy samples taken at 2-monthly intervals from lambs given 1.5 g of copper oxide needles at 4-months of age (December) and a further 2 g at 8 months (April) are shown in Table 2.

SELENIUM PELLETS

Selenium pellets developed by CSIRO in the late 1960s, and composed of 5% elemental selenium and 95% finely divided iron, were reported to prevent signs of selenium deficiency in sheep for more than 3 years(6). However trials with commercially produced pellets in both New Zealand (Grant, unpublished data) and Australia(11.16) showed that they were effective for only 10-12 months.

In 1981 CSIRO workers demonstrated that the grain size of selenium in the pellet was a major factor in the duration of effectiveness(10). The release of selenium to the animal is considered to depend on the reaction 3 Se + 2 Fe + 2 H2O → FeSe2 + H2Se + Fe(OH)2, taking place within the pellet in the rumen. Of the three forms of selenium present, only selenium in the forms of H2Se is thought to be available to the animal. Most commercial pellets contained selenium of small grain size, and consequently the reaction takes place rapidly. An average size of about 40 μm was suggested as optimal to ensure elevated selenium levels in sheep for periods of a year or longer(10).

A trial to evaluate the efficacy of a batch of selenium pellets manufactured with selenium of the recommended grain size (PermaseI, ICI Australia) has just been completed at the Wairakei Research Station (a severely selenium deficient area). The pellets were judged to be ineffective when blood selenium levels fell below 20 ng/ml, the value below which selenium responsive conditions can be expected in sheep. Retention of pellets was confirmed by radiography and recovery at slaughter. The results are summarised in Fig. 2.

Of the pellets recovered from slaughtered sheep, half were partially coated with calcium phosphate. However the coating did not always account for reduced effectiveness.

New and recovered pellets are being examined to determine if physical or chemical differences in pellet composition account for the large variation in observed performance.
These results support published data using greater dose rates (12) which showed that copper oxide needles were an effective method of elevating liver copper levels in sheep. However this treatment must be used with caution to prevent copper toxicity.

Slow release systems designed for oral administration to sheep show potential, but those developed to date all have limitations and scope for further research is still considerable.

Table 1: Mean body-weights, and levels of selenium in the blood, copper in the liver and vitamin B, in the liver and sera of control sheep (10) and sheep given soluble glass pellets (30). SD in brackets.

<table>
<thead>
<tr>
<th>Group</th>
<th>Time</th>
<th>Weight kg</th>
<th>Blood Se ng/ml</th>
<th>Serum B, pmol/l</th>
<th>Liver Cu mg/kg</th>
<th>Liver B, nmol/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>December</td>
<td>19.7(2.1)</td>
<td>58(27)</td>
<td>NS</td>
<td>48(24)</td>
<td>753(266)</td>
</tr>
<tr>
<td></td>
<td>February</td>
<td>25.1(2.7)</td>
<td>29(15)</td>
<td>NS</td>
<td>105(28)</td>
<td>295(103)</td>
</tr>
<tr>
<td></td>
<td>April</td>
<td>28.4(2.4)</td>
<td>13(7)</td>
<td>846(348)</td>
<td>87(33)</td>
<td>229(96)</td>
</tr>
<tr>
<td></td>
<td>June</td>
<td>35.0(3.8)</td>
<td>9(3)</td>
<td>449(167)</td>
<td>89(35)</td>
<td>302(74)</td>
</tr>
<tr>
<td>Pelleted</td>
<td>December (30)*</td>
<td>20.2(2.0)</td>
<td>57(22)</td>
<td>NS</td>
<td>43(19)</td>
<td>627(140)</td>
</tr>
<tr>
<td></td>
<td>February (29)*</td>
<td>27.3(2.2)</td>
<td>219(52)</td>
<td>NS</td>
<td>184(71)</td>
<td>317(103)</td>
</tr>
<tr>
<td></td>
<td>April (23)*</td>
<td>32.5(3.1)</td>
<td>316(58)</td>
<td>1523(609)</td>
<td>213(73)</td>
<td>354(140)</td>
</tr>
<tr>
<td></td>
<td>June (16)*</td>
<td>39.4(2.6)</td>
<td>311(54)</td>
<td>928(435)</td>
<td>206(74)</td>
<td>392(147)</td>
</tr>
</tbody>
</table>

* Number of sheep with pellets confirmed by radiography.
NS — Not sampled.

Table 2: Mean liver copper levels of 14 control sheep and 15 sheep dosed at 4 months of age and again at 8 months with 1.5 and 2.0 g of copper oxide needles respectively. SD in brackets.

<table>
<thead>
<tr>
<th>Group</th>
<th>Liver Cu (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>December</td>
</tr>
<tr>
<td>Control</td>
<td>33(10)</td>
</tr>
<tr>
<td>Copper oxide</td>
<td>39(20)</td>
</tr>
</tbody>
</table>

REFERENCES

Fig. 1: Mean liver (a) and serum (b) vitamin B$_2$ levels for groups of 12 sheep receiving cobalt pellets (———); 3-weekly injections of 1 mg of hydroxocobalamin (△△△); weekly drenches of 7 mg of cobalt as the sulphate (-----) or chelate (-----); or no treatment (o--o). The shaded area indicates the range of marginal deficiency.
Fig. 2: Median blood selenium levels for control (——) and pelleted sheep (−−−). The performance of the best (−−−−) and worst (−−−−−) of the pelleted sheep have been included, together with the percentages of animals with blood selenium levels < 20 ng/ml on the days indicated (▼).