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GAMMA-IRRADIATED SEWAGE SOLIDS AS FEED FOR RUMINANTS¹⁾

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SUMMARY Dried solids from primary sludge in domestic municipal sewage were disinfected by gamma-irradiation and used effectively as supplemental feed for cattle and sheep in practical, long-term studies of reproductive performance, with negligible evidence of toxicity and heavy metals accumulation. Sewage products contained about 20% crude protein, which was digested and retained as well as protein in cottonseed meal.

INTRODUCTION Increased usage of novel resources as feed for animals seems vital toward meeting human food needs in the future (6). Sewage represents a vast resource of nutrients that could be used in animal feed (3,10) when technology based on science is applied to assure product efficacy and safety (2). This report summarizes main results from a seven-year research program which assessed nutritive value of dried, gamma-irradiated solids from primary sewage sludge and the risks of toxicants in long-term trials with cattle and sheep (1,4,5,7-12).

MATERIALS AND METHODS Primary sludge was collected at the sewage treatment plants of Albuquerque and Las Cruces, NM, where sewage is mainly domestic and low in industrial contaminants. Air-dried solids were gamma-irradiated at facilities of Sandia National Laboratory to about one megarad, which effectively minimized risks of viable parasites and pathogenic organisms (8). Sewage products were analyzed for nutrients, trace elements, heavy metals and 22 refractory halogenated-hydrocarbons. Major batches used in animal trials were tested for toxicity to rumen microbes and to rats in bioassays of growth and reproduction. Digestibility of energy, protein and fiber, and retention of N were assessed in trials with sheep. Effects of products on intake and digestibility of fibrous roughages were assessed with penned sheep and penned or grazing cattle. Carcass quality and tissue levels of heavy metals and organic toxicants were assessed in feeding trials with sheep and cattle, in some of which impractically high levels of sewage product were fed to determine risks of toxicants. Beef from cattle fed 12% sewage solids for 68 days was fed to rats in a 3-generation study of beef wholesomeness and safety. Pelleted supplements with 50 or 60% sewage solids were fed to gestating-lactating beef cows grazing arid rangeland, during three to four months each year when forage was lacking in protein, throughout five years. Breeding fine-wool ewes in drylot were fed pelleted, complete feeds, in which sewage solids comprised 7% of diet in replacement of 3.5% cottonseed meal, continuously throughout a four-year study of reproductive performance. All animal trials involved comparisons with positive controls fed cottonseed meal and negative controls fed basal diets. Toxicological evaluations included animal growth and feeding performance, reproduction, blood serum clinical profiles, histopathology, and hepatic mixed-function oxygenase, epoxide hydrolase, and various conjugase activities.

RESULTS AND DISCUSSION Numerous batches of sewage solids were collected and fed during the seven-year period. Median values for chemical components are as follows (% dry basis): crude protein, 20; acid-detergent fiber (ash-free basis), 28; ash 36; acid-insoluble ash, 24; lignin, 8; ether extract, 7; Ca, 1; P, 0.5; Fe, 0.5; Mg, 0.16; K, 0.15; and Na, 0.10. Median values (ppm, dry basis) for trace elements were: Zn, 532; Cu, 324; Pb, 120; Cr, 118; Mn, 82; Ag, 17; Ni, 15; Co, 7; Cd, 5; Hg, 1.8 and Se, <1. *Aspergillus* and other molds developed in some batches while air-drying, but tests for aflatoxins were negative. Gross energy (4.1 kcal/g) was 60 to 65% digestible by ruminants. True digestibility of N in sheep was about 80%. Retention of absorbed N was 60 to 65% when sewage products supplied most of the N and when supplied to meet or exceed N requirements. Intake and digestibility of fibrous roughages were generally improved by supplemental sewage solids, to about the same extent as occurred with supplemental cottonseed meal. Slaughter trials with sheep and cattle fed impractically high levels of sewage solids

revealed no overt toxicity and only slight accumulations of metals except Fe which accumulated and diminished liver and kidney Cu levels. Sheep fed sewage solids as 50% or more of total diet, for three months or more, exhibited symptoms of chronic toxicity including decreased feed intake, increased urine volume, serum clinical profile changes and histological abnormalities in livers and kidneys, seemingly related to excessive Fe. Liver vitamin A was diminished in sheep fed excessive amounts of sewage products. Beef cows were fed pelleted supplements containing about 50% sewage solids plus conventional ingredients for 3 or 4 months during gestation and lactation while grazed forage lacked quality. Reproduction was improved markedly over non-supplemented controls during three years of the five year study, but was diminished below unsupplemented controls in one year when vitamin A deficiency (evident in all treatment groups) was exacerbated by the supplement with sewage solids. Fifty fine-wool ewes in drylot consumed pelleted, complete diets containing sewage solids as 7% of dry matter, in replacement of 3.5% cottonseed meal, throughout four years with no adverse effect on reproduction or wool yield; although wool quality (fineness) was diminished slightly. Hematology, serum clinical profiles, organ uptake of heavy metals, halogenated hydrocarbons in renal fat, liver mixed function oxygenase, epoxide hydrolase and acetyl-, sulfo-, glutathionyl- and UDP glucuronosyl- transferase activities did not differ from positive controls fed the same basal ingredients and cottonseed meal. Preweaning and postweaning growth of lambs from ewes fed 7% sewage solids did not differ from controls during the first two years, but weaning weights in the last two years were 15% below controls. Feeding performance of lambs fed 7% sewage solids was diminished slightly below controls but carcass quality was not impaired and heavy metals accumulation were slight or negligible. Beef from cattle fed 12% sewage solids caused no adverse effects on growth, reproduction, organ weights or histopathology of rats in a 3-generation study using beef as 10, 20 or 30% of diet. Our findings show that low-cost, low-risk feedstuffs can be developed from municipal (domestic) sewage. Nutritive energy and nitrogen in products we tested were one-half to two-thirds as much, dry weight basis, as in cottonseed meal. Improved technology could provide products considerably better. Risks from toxicants in our products seem remarkably lower than those in sludges selected from industrialized municipalities. Among the critical issues facing animal scientists worldwide (2,6) is an urgency for valid data to rebut invalid constraints on usage of agricultural resources that are novel or marginally contaminated.

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