

NUCLEAR TECHNIQUES IN ANIMAL PRODUCTION AND HEALTH AND FOOD IRRADIATION

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INTRODUCTION

Nuclear techniques applied to animal production and health are concentrated in three main fields: Animal nutrition, reproduction and animal health. Isotopic markers, both radioactive (^{14}C , ^{51}Cr , ^{32}P and ^{35}S) and stable (^{15}N), have been used in the development of feeding strategies by understanding the rumen fermentation process, and how protein and other nutrients are utilized to determine a balanced diet for meeting animal requirements for growth, pregnancy and lactation. The simple and easily applicable technology was developed for the preparation of a urea mineral multivitamin block as a supplement and animal cake for the replacement of concentrate feed used by dairy cattle holders. The model was developed in Yerli Kara Cattle and its cross-breeds to estimate protein requirements of animals. Progesterone immunoassays (RIA/EIA) make it possible to control the reproductive performance of cattle, sheep and goats. A milk progesterone enzyme immunoassay kit known as Reprokon was developed at our Center. The kit has been licensed by the Ministry of Agriculture and Rural Affairs. As for animal diseases, especially parasitic infections, nuclear techniques have proved to be of great value, namely in the production of irradiated vaccines against helminthic diseases. The Enzyme Linked Immunosorbent assay (ELISA) diagnostic techniques were used on the diagnosis of babesiosis, a disease which causes great economic loss in livestock in Turkey.

Food irradiation is the treatment of raw, semi-processed or processed food or food ingredients with ionizing radiation to achieve a reduction of losses due to insect infestation, germination of root crops, spoilage and deterioration of perishable produce, and/or the control of microorganisms and other organisms that cause foodborne diseases.

ANIMAL NUTRITION

Commonly used radioisotope labelling techniques for the measurements of metabolites of energy, protein and mineral metabolisms are summarized as follows:

- Volatile Fatty Acid (VFA) Production rate: ^{14}C -VFA
- Microbial Protein Synthesis (MPS): ^{35}S , ^{32}P , ^{15}N , ^{14}C -Glucose, ^{14}C -Uric acid, ^{15}N -uric acid
- Organic Matter Digestibility: ^{14}C -PEG, ^{51}Cr -EDTA, ^{14}C -EDTA
- Rumen fluid volume: ^{51}Cr -EDTA, ^{14}C -EDTA, ^{60}Co -EDTA, ^{14}C -PEG
- Minerals: AAS, RIA (B_{12} , Ferritin) In-vitro radiomineral Uptake (^{65}Zn , ^{75}Se , ^{59}Fe)

Recent developments in energy and protein evaluation systems from different countries are based on in-vivo and in-vitro techniques to use feedstuffs efficiently. And to meet the nutrient requirements of ruminants, commonly used forages, roughages, protein

rich feeds and agro-industrial by-products (poultry manure, whey, fruit pulps, sugar beet pulp, oil seed meals, wheat bran, straws) were evaluated. Their rumen degradable and undegradable protein fractions, OM and DM digestibilities and effects upon MPS and VFA production rate were studied with feeding trials. Blood metabolites related to nutrition (BHB, Alb, Glb, Urea and P) and metabolic diseases (ketosis, metritis, mastitis, foot infection, parasites) were investigated in dairy cattle under field conditions. The effects of evaluated feeds on production in goats, sheep and cattle were also followed by controlled feeding experiments. Developments on supplementation strategies are on progress.

Purine derivatives (PD) excretion is related to feed intake and PD excretion could be used as an index to estimate microbial protein supply as well as to measure DDMI or DOMI in Yerli Kara cattle. The endogenous excretion was estimated as 0.691 mmol/kg $W^{0.75}$ /d and the average recovery of injected 8- 14 C-uric acid in urine was 0.81. Hence the following model is suggested for Yerli Kara cattle of Turkey:

$$\text{PD excretion (Y mmol/d)} = 0.81 \times (\text{PD absorption, mmol/d}) + (0.691 W^{0.75}).$$

Development of feeding strategy

In order to develop a feeding strategy for dairy cattle a survey was conducted on smallholder dairy herds of Holstein cows fed on commercial concentrates and crop residues such as barley straw or wheat straw. The objective of the survey was to establish constraints to productivity by determining the nutritional, reproductive and health status of herds. At the start, data on herd size, animal housing, age and parity of cows, feeds and feeding and other management practices on smallholder farms located in a periurban area were collected and recorded. Nutritional status was assessed by records of blood metabolites determined at three critical times and of body weights and condition scores determined monthly. Also, rumen degradability of feeds was determined and concentrate intakes of cows were recorded. As production proceeded, measures of herds lactation milk yields and calving intervals of cows were assessed and recorded.

Reproductive events were followed via the measurement of progesterone by radioimmunoassay. The occurrences of mastitis, metritis, retained placenta, ketosis, and foot infection were recorded to gauge the health status of the cows. Although the cows were kept housed and tied, by feeding straw as the sole source of roughage and high amounts of starch based concentrates, the milk production and calving intervals of the herds were maintained at acceptable levels; but the health status of the herds deteriorated, as indicated by a high incidence of production diseases.

Because only a few cows in a smallholder herd are at critical sampling stage, blood metabolic profile testing takes a long time. The test is useful in assessing the nutritional status of herds in a long term, but it is of limited value for taking preventive measures in smallholder herds for intervention and for preventing the losses in productivity due to nutritional deficiency or imbalance. Based on the results of the survey under zero grazing conditions, it is recommended that the roughage intake and utilization be increased by appropriate supplements, and protein concentrate without grain be prepared and used in the area. Supplements of dried sugar beet pulp and grain in a crushed but not finely ground form should be included into the diets, separately,

and in required amounts.

A simple and easily applicable technology was developed for the preparation of urea-mineral-multinutrient blocks as a supplement and animal cake for the replacement of concentrate feed to use by dairy cattle holders.

REPRODUCTIVE PHYSIOLOGY

Since early diagnosis of non-pregnant animals, timing of artificial insemination, silent heat, embryonic deaths, ovarian cysts are not being detected properly, parturition rate is very low in Turkey. Research studies showed that silent heat (60%) was the most common problem in dairy cows. By using the progesterone kit developed in our laboratory, the pregnant and non-pregnant animals were diagnosed to within 90% accuracy. Various applied research studies were also carried out to improve reproductive performance and to diagnose reproductive disorders by using RIA/EIA-milk progesterone kits in mares, Angora goats, Sakız sheep and in other farm animals.

ANIMAL DISEASES

Diagnosis of some important parasitic and bacterial diseases by using serological techniques such as ELISA, elimination of food-borne parasites by irradiation and immunization studies against animal parasites by irradiated larvae, have been investigated in general.

Immunization Studies

First, experimental animals were mono-specifically infected to obtain the necessary parasitic larvae. Then, the parasite eggs and larvae were irradiated to examine the effects of irradiation on the parasites. In studies using *Trichostrongylus spp.* and *Nematodirus spp.*, it was observed that there is an inverse relationship between the gamma radiation dose used and larval development, i.e. higher the applied radiation dose, greater the larval death rate.

Moreover, immunization studies were performed using radiation-attenuated larvae against *D. filaria* and *T. colubriformis*. As a result, there was a high protection against *D. filaria* in guinea pigs and 64–72% protection against *T. colubriformis* in lambs. In addition to these, vaccination studies were carried out against *B. ovis* in sheep in cooperation with the CSRIO Institution of Australia and IAEA.

The efficacy of some antiparasitic drugs were investigated using larvae obtained from monospecific infections. Additionally, the cryopreservation of these larvae was studied. It was that the percentage of surviving larvae was found to be 29% after storage in liquid nitrogen for 249 days. However, the infectivity of these larvae was poor.

Prevalence Studies

The ELISA diagnostic technique were used on the diagnosis of babesiosis, a disease that cause great economical losses in livestock. In seroepidemiological surveys, it was found that the prevalence of babesiosis is 51% in cattle and 60% in sheep. The geographical distribution of this disease has been studied so as to determine the most prevalent regions in Turkey.

Possibilities of the use of ELISA test on the serodiagnosis of *C. bovis* and *F. hepatica* had been investigated. It was shown that the ELISA test could not be used to determine such low-level infections.

Determinations of the prevalence of *Sarcocystis spp.* and *Cryptosporidium spp.* parasites were studied by meat and fecal examinations, respectively. *Sarcocystis* infection rate was 95% and the other infection had a prevalence of 65%.

FOOD IRRADIATION

Foods have been preserved via various methods for ages. Such methods include cooking, drying, salting etc. However, with the increase of the world population, new alternative food preservation techniques are needed, e.g. food irradiation. Food irradiation is accepted as a physical process and thought to be the best preservation technique for some types of food or food products. Increase in production will also bring along problems of preservations. Moreover, many countries have banned, or are about to ban, various fumigants identified as health hazards. As such, irradiation can and should be thought as a serious alternative method in food preservation. Food irradiation may gradually become a widespread application fields throughout the world, yet only laboratory studies have been performed in Turkey. Food irradiation is used for the following purposes: to preserve the physical, chemical and hygienic qualities of foods; to eliminate the spoilage and pathogenic microorganisms; to inhibit the sprouting, insect disinfestation in vegetables; to delay the ripening and physiological destruction in fruits; and to extend the shelf-life of foods.

Furthermore, studies have been carried out on the effects of ionizing radiation on biological materials and bacteria.

Effects of Gamma Irradiation on the Shelf-Life Extension of Foods

Results of the studies carried out on the effects of gamma irradiation on the shelf-life extension of foods could be summarised as follows: the shelf-life of vacuum packed - fresh anchovy could be extended for 9–13 days via 1 kGy of irradiation. It was demonstrated that the shelf-life of vacuum packed fresh chicken breast meat exposed to a radiation dose of 2.5 kGy at 4 °C can be extended 7–14 days. The shelf life of Turkish fermented sausages prepared by starter culture and raw material, irradiated at 1 kGy was extended for a month after maturation. Moreover, the shelf life of canned meat packed with NaNO₂ and irradiated at 3 kGy was extended 5–6 times compared to controls. Also, storage life of fruits and vegetables could be increased by irradiation treatments and the cost of this treatment is only about 3–6 % of the price of the product.

Effects of Gamma Irradiation on Microorganisms and Parasites

It was found that a 10 kGy dose of radiation could reduce the microbial contamination significantly in food additives such as red and black peppers. 3 kGy radiation dose is required for the elimination of *Salmonella*, *Campylobacter*, *E. coli* and *S. aureus* in chicken meat. *Aspergillus flavus* invasion can be controlled in dried figs by irradiation doses ranging from 3.5 to 10 kGy.

Observations showed that 3.7–6 kGy of irradiation doses were required to devitalize *C. bovis* cysts in meat; however, it was concluded that 0–3 kGy could be accepted as the

minimal effective dose to inhibit the development of *C. bovis* larvae into adult tapeworms.

Besides, various stages of figworms (*Cadra cautella*) were eliminated by irradiation with a dose range of 1–1.4 kGy in dried figs.

The Combined Food Preservation Process Design

Studies are being carried out on the inactivation kinetics of thermo-radiation processes (combined treatment of heat and radiation) to control the microorganisms in food.

Detection of Irradiated Foods

The irradiated chicken meats and irradiation doses absorbed by that meat were detected with ESR spectroscopy technique. Studies using ESR and thermoluminescence techniques are in progress.

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