

Neutron activation analysis of zinc in forages used in intensive dairy cattle production systems

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Instrumental neutron activation analysis (INAA) was applied for the determination of Zn concentration in the main tropical grass forages used in intensive dairy cattle production systems, in Brazil. Smaller Zn concentration could be verified in the rainy period. Comparison of results obtained in these analyses of forages dry matter with daily requirements pointed towards deficiency of Zn in the forages.

Introduction

Zinc takes part in countless metabolic events, as it is located at the active site of a great number of metalloenzymes, acts in the catalytic processes, and plays also a role in the configuration of DNA and RNA.¹ Recently, it was verified that zinc is related to the recovery ability of the hoof tissue and to the growth rate of the hoof, in the case of cattle.²

In the last years, due to productive and economic reasons, dairy cattle was gone through great transformations related to nutrition, to the genetic standard of the herds and to facilities. This resulted in a larger animal concentration, and a larger competition among them. This resulted also in an accumulation of animal wastes, predisposing the animals to a larger number of diseases, like the hoof affection.² This causes an animal discomfort, limiting of locomotion, and is generating significant economic losses. Among them a decrease of dairy cow longevity, increasing the annual discard rate of the herd.

Due to the importance of zinc in animal nutrition and production, the main goal of this work was to evaluate the Zn concentration in the main forages used in intensive dairy cattle production systems, in Brazil.

The analytical method used to determine zinc was instrumental neutron activation analysis followed by gamma-ray spectrometry. INAA is a method that involves a minimum of sample handling and has been applied to the analysis of biological material by several researchers^{3–6} during the last few years.

Experimental

Sampling protocol, collection and treatment of the sample

This part of the work was carried out by the Southeast Cattle Research Center of EMBRAPA, located in São Carlos, São Paulo State, Brazil, under tropical altitude climate.

Forage species used in this study were: Brachiaria (*B. decumbens*), Tobiatã (*Panicum maximum*) and Batatais (*Paspalum notatum*), cultivated in different kind of soils and management, as shown in Table 1.

The plant part above ground, composed by leaves and slender stem, was considered in this work. Samples were collected 7 cm above soil surface. The sampling dates were: 02/03/98, rainy season, and 08/04/98, dry season, in a monthly cutting series.

Parts of the samples destined for zinc determination, were dried at 60 °C with forced air circulation. The dried materials were ground in Willey mills and passed through a 20-mesh sieve (0.84 mm).

For irradiation, 200 mg samples were transferred to polyethylene envelopes, after previous treatment with p.a. HNO₃ 1:5, to eliminate probable impurities.

Zinc standard preparation

The zinc standard was obtained by the dissolution of metallic zinc, (Johnson Matthey) with HNO₃, Merck, and final dilution with distilled water. An aliquot of 50 µl was transferred, with micropipettes, to an 1.5 cm² surface Whatman N.41 filter paper. After drying, the filter papers were placed into clean polyethylene bags. The prepared standard contained 24.3 µg of zinc.

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Table 1. Forage species, soil type and management

Soil	Forage/Management	Code name
1. Ferralic Arenosol (FA)	Brachiaria	1FAB
2. Orthic Ferralsol (OF)	Brachiaria	2OFB
3. Orthic Ferralsol (OF)	Brachiaria with intense fertilization	3OFBF
4. Orthic Ferralsol (OF)	Tobiatã	4OFT
5. Orthic Ferralsol (OF)	Tobiatã with intense fertilization	5OFTF
7. Orthic Ferralsol (OF)	Batatais	7OFBA
9. Rhodic Ferralsol (RF)	Brachiaria	9RFB
10. Rhodic Ferralsol (RF)	Batatais	10RFBA
11. Rhodic Ferralsol (RF)	Tobiatã	11RFT
12. Luvisol (L)	Brachiaria	12LB
13. Luvisol (L)	Batatais	13LBA

Note: After FAO soil classification: B – Brachiária; T – Tobiatã; BA – Batatais.

Table 2. Zinc concentration (in $\text{mg}\cdot\text{kg}^{-1}$) measured in forages by INAA

Forage	Sampling: 02/03/98 (rainy season)	Sampling: 08/04/98 (dry season)
1FAB	17	25
2OFB	14	24
3OFBF	16	17
4OFT	12	14
5OFTF	22	24
7OFBA	22	26
9RFB	18	26
10RFBA	14	20
11RFT	13	18
12LB	16	35
13LBA	12	22

Irradiation and counting

Five plant samples and the zinc standard were irradiated together in nylon containers, under a thermal neutron flux of $3\cdot 10^{12} \text{ n}\cdot\text{cm}^{-2}\cdot\text{s}^{-1}$, in the IEA-R1 reactor. Samples and zinc standard were transferred to a proper container for gamma-radiation measurement. Measurements were carried out after a decay time of 10 days. The ^{65}Zn radionuclide was measured at the 1115.5 keV photopeak.

The equipment used to measure the gamma-radiation was a Canberra model GX2020 with a hyperpure Ge detector coupled to a model 1510 Integrated Signal Processor and MCA System 100, both from Canberra. The detector used had a resolution (FWHM) of 0.9 keV for the 122.1 keV gamma-ray of ^{57}Co and 1.9 keV for 1332.5 keV gamma-ray of ^{60}Co . Data reduction was carried out using an IBM/PC microcomputer and VISPECT2 software in Turbo Basic language for spectral analysis.

Results and discussion

The certified reference material Peach Leaves (NIST SRM 1547)⁷ was analysed to verify the accuracy of the method. The deviation of the arithmetic means of four zinc determinations from the certified value, was found to be approximately 4%.

Two zinc determinations were done for each forage sample. The individual error of each analysis, considering the statistical counting, varied from 1 to 2% and the error between both repetitions varied from 1 to 10%. Table 2 presents the mean zinc concentration, $\text{mg}\cdot\text{kg}^{-1}$, for the forages (Table 1).

A tendency of smaller zinc concentration could be verified in the rainy period, when zinc supplementation could be proportionally increased. According to the literature,⁸ it is not known whether genetic differences have an effect on the zinc requirement of cattle. The zinc requirement of the ruminant varies with the chemical form or combination in which the element occurs with other components of the diet. Visible symptoms were found in cattle under grazing, when the diet was constituted by forage zinc contents between 18 and $42 \text{ mg}\cdot\text{kg}^{-1}$ in the dry matter.⁹ These symptoms may cause a reduction in the quality of the leather. Studies showed that the combination of zinc with specific amino-acids could result in a promising additive. The use of these compounds as supplement to dairy cows diet seems to increase productivity and the quality of the hoof.¹⁰ The daily requirement suggested for the dairy cattle is $40 \text{ mg}\cdot\text{kg}^{-1}$ of zinc in the dry matter.⁸ This requirement should satisfy the needs of the animals in many situations, such as age and management.

The knowledge of zinc concentration in forages, main source of food for ruminants, is important for a wise supplementation of the element, although the tolerable maximum limit for zinc is $500 \text{ mg}\cdot\text{kg}^{-1}$ in feed.⁸ In addition, the anti-economic supplementation above the needed one can cause future environmental problems, due to the accumulation of not absorbed zinc by the animals and released as excrement and urine.

Conclusions

When tropical forages are used in dairy cattle feeding, the diet should be commonly supplemented with zinc. Instrumental neutron activation analysis shows to be a very adequate method to determine zinc in forages, due its good accuracy, and its sensibility to detect small variations in the concentrations of this element.

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