# Minerals and Oxalate content of feed and water in relation with ruminant urolithiasis in Adea district, central Ethiopia

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**SUMMARY**

A study on the mineral and oxalate level of feed and chemical composition of drinking water of ruminants was made in relation with urolithiasis. The study involves two different animal production scenarios (rural traditional cattle farming and intensive production sheep feedlot) in selected sites in Adea district, central highlands of Ethiopia where the problem is reported to occur. Detailed assays were conducted on crop-residues used as dry-season cattle feed (minerals and oxalate) and concentrate as a fattening ration of rams (minerals). The mineral concentration of water used for drinking animals for both species was also carried out. The assay results were computed and analysed by comparing with normal literature values determined for the species (cattle/ sheep). The findings revealed that the overall mean oxalate content of teff (*Eragrostis tef*) straw (5.27 ± 2.07 g/kg) was by far greater than its respective mean calcium content (2.91 ± 1.50 g/kg) and the calcium to oxalate ratios was hence computed as less than one (0.67). Other studied straw types, except mixed straw-1, also showed calcium : oxalate ratio less than 2. This indicates the likely excess in oxalate level. Higher mean Oxalate levels (5.93 ± 1.93 g/kg) were obtained from teff straw samples of Dukem Koticha as compared to that of Dire site (3.50 g/kg). Phosphorus was found to be deficient in all the crop-residue samples. Analysis of all the concentrate feeds used for fattening rams was found to contain excess phosphorus and magnesium, and their calcium : phosphorus ratio was also below the minimum requirement. However, the mean phosphorus concentration of mixed-grain flour was found to be considerably lower than the other concentrate feeds. With the exception of magnesium, the mineral compositions of wheat bran and mixed-grain flour were found to be different. The mean values of the mineral concentration of water used for animals in the study areas were within the recommended water quality for livestock. Results were discussed by comparison with literature data from other countries. Recommendations on possible control options and future area of research were made.

**KEY-WORDS : urolithiasis - cattle - sheep - food - water - minerals - oxalates - Ethiopia.**

**RÉSUMÉ**

**Teneurs en minéraux et en oxalates des aliments et de l'eau de boisson distribués au bétail de la région d'Adée, Ethiopie. Relation avec l'urolithiase. Par R. TIRUNEH.**

Cette étude présente les teneurs en éléments minéraux et en oxalates des aliments ainsi que la composition chimique de l'eau de boisson distribués au bétail et leurs effets potentiels sur le développement d'une urolithiase. Ce travail a été conduit sur des animaux issus d'élevages fermiers traditionnels ou d'élevages intensifs localisés dans le district d'Adée (région centrale de l'Ethiopie) dans lequel l'urolithiase survient fréquemment. Les teneurs en minéraux et en oxalates des résidus agricoles utilisés dans l'alimentation des bovins pendant la saison sèche ainsi que celle en minéraux des concentrés distribués à l'engraissement des moutons ont été déterminées de même que les concentrations en minéraux de l'eau de boisson.

Les résultats obtenus ont été comparés avec les données disponibles dans la littérature pour ces 2 espèces. La teneur moyenne en oxalate (5.27 ± 2.07 g/kg) du foin d'*Eragrostis teff* fut très supérieure à celle de Ca (2.91 ± 1.50 g/kg) conduisant à un rapport Ca / oxalate nettement inférieur à 1 (0.67). En outre, la quantité d'oxalate trouvée dans le foin de la région de Dukem Koticha (5.93 ± 1.93 g/kg) fut plus élevée que celle du foin de la région de Dire (3.50 g/kg). Les autres types de foins étudiés ont, le plus souvent, présenté un rapport Ca / oxalate inférieur à 2, ce qui indique probablement un excès d'oxalate. La teneur moyenne en phosphates fut insuffisante dans tous les résidus alimentaires testés. L'analyse des concentrés destinés aux ovins a révélé une teneur excessive en phosphates et en magnésium ainsi qu'un rapport Ca / Phosphates au-dessous de la recommandation minimale. La concentration moyenne en phosphates de la farine de grains mélangés fut considérablement plus faible que celle des autres concentrés. À l'exception de la concentration en Mg, la farine de blé et celle de grains mélangés ont présenté des concentrations minérales différentes. Les concentrations moyennes des minéraux mesurées dans l'eau de boisson du district d'Adée furent compatibles avec les recommendations sur la qualité de l'eau. Ces résultats ont été confrontés avec ceux de la littérature obtenus dans d'autres régions ou pays et des recommandations alimentaires ont été établies.

**MOTS -CLÉS : urolithiase - bovin - ovin - alimentation - eau - mineraux - oxalates - Ethiopie.**

# Introduction

Urolithiasis refers to the presence of calculi in the urinary system. The disease commonly occurs in ruminants and invariably results in blockage of the urethra in male subjects [12]. Urinary stones or uroliths are one of the commonest causes of urethral obstruction and results in retention of urine, difficulty of urination, distention and rupture of the urinary bladder, and death in untreated cases [15]. Surgical treatment is palliative that is only to provide a temporary relief from obstruction and or uremia. Urolithiasis, in countries like Ethiopia, presents an important economic repercussion where cattle-based agriculture is strongly linked with the livelihood of an important segment of the population. Losses are associated with the high mortality rate and condemnation of urineous carcass [12, 15].

The cause of urinary calculosis is complex and results from several interacting factors. Generally, nutritional and environmental factors are anticipated to play significant role in the formation of uroliths in domestic animals [20]. High level of oxalates and silica in pasture plants were considered as major factors in urolith formation of grazing animals [18, 21, 22]. On the other hand, provision of concentrate ration, which is typically rich in phosphorus, or when there is an imbalance in calcium and phosphorus ratio, were stated as major causes of urolithiasis in feedlots [11, 13]. CUDDFORD [8] mentioned about the role of high level of magnesium as principal causes of urinary calculosis in concentrate fed lambs. In addition to dietary causes, there are a number of predisposing and contributing factors, includes the ones that could precipitate calculi formation such as inadequate intake of water and drinking of highly mineralized water [26]. Dehydration in times of draught can also promote urolithiasis by way of urinary concentration and thus lead to the development of urinary calculi [5]. ROMAN [27] reported high prevalence of urolithiasis in cattle in localized areas in Adea district and among traditionally managed sheep feedlot put on concentrate ration. According this recent study, urolithiasis was the single most prevalent surgical condition and economically important disease of ruminants. The above stated causal, predisposing and contributing factors are anticipated to occur. The present study was, thus, undertaken the clue to the determination of factors involved in ruminant urolith formation in two different animal production scenarios (extensive traditional cattle management and intensively managed sheep feedlot). The study is conducted in selected sites in Adea district, central Ethiopia where the disease is reported to be a major constraint to ruminant productivity. The specific objectives of this study is to determine the minerals and oxalate levels of a variety of crop-residues used as dry season cattle feed, to evaluate the mineral composition of traditionally used mixed-grain flour from the mill house and commercially prepared concentrate ration used as a basal diet for fattening rams and the mineral composition of different water sources (lake, river, pond and tap) used for animals in the study areas.

# Materials and methods

## THE STUDY AREA AND ANIMAL MANAGEMENT

The study was conducted during the dry season of the year (February to June 2000) where ruminant urolithiasis is confirmed to occur [27]. Based on prior information on the disease the study sites were selected to represent two different ruminant production scenarios where urolithiasis is reportedly prevalent. These are : a/ extensive traditional cattle production (Dukem Koticha, Kurkura and Dire peasant association) located within 10-35 km distance from Debre Zeit town. b/ Small-scale intensive sheep fattening farms (Debre Zeit town). Generally the study area is classified as mid-altitude zone (1850 m.) with mean minimum-maximum daily temperature vary between 11.8 - 26.9°C and an annual rainfall of 815 mm.

In the extensive mixed farming system crop residues form the principal dry season feed. There is crucial shortage of grazing pasture and drinking water during the long dry season and heavy reliance on crop-residues. Provision of water to cattle is often made once in 2-3 days and often involving long distance travel (except in Dukem Koticha). Animals from these sites depend either on lake (Kurkura), stream (Dukem Koticha) or pond (Dire) water sources. Commercially prepared concentrate and traditionally obtained mixed grain flour from the mill house are used as basal diet for fattening rams in the study area (Debre Zeit town). Roughage is provided to these animals on occasional basis where as water from pipe is available all the time.

## ASSAY SAMPLES AND ANALYTICAL PROCEDURES

Samples of crop-residues and concentrates used as ruminant feed were collected from the identified study areas. Accordingly, a total of 16 crop-residues including teff (*Eragrostis tef*) (11), wheat (2), 'Dagussa' (*Elevisine coracane*) (1) and mixed straws (2) were collected from the two rural sites (Dukem Koticha and Dire). The mixed straw sample designated as mixed-straw-1 collected from Dukem Koticha site was a mixture of 'Guaya' (*Lathyrus sativus*), wheat and barley straw, whereas mixed-straw-2 from Dire site was a mixture of bean, pea and wheat straw. The proportion of the mixture was not known. Due to technical reasons, samples of feed were not collected from Kurkura peasant association. In addition, a total of 7 concentrate feed samples comprising wheat bran (3), mixed grain flour (2), mixture of 'Noug' (*Guizotia abyssinica*) and sunflower cake (1) and linseed cake (1) were collected from commercial sources and mill houses in Debre Zeit town. The proportion of the mixture of the noug and sunflower cake was not known. All the samples were collected by polling core samples from 9 positions within the stack. Each crop-residue sample consists of 1 kg while the concentrate feed each weighing 2 kg. The samples were sent to Ethiopian Health and Nutrition research institute (EHNRI) for analysis.

In both production scenarios, the feed samples were subjected to standard analysis to determine its oxalate and mineral content (crop-residues) and mineral concentration (concentrate feed). All the feed samples were first homogenized using an Osterizer (oster, USA). Crop-residue samples were first cut into small pieces using stainless scissors. Dry matter of the concentrate feeds and crop-residues was determined after drying to constant weight in an oven at 105°C and 60-70°C, respectively. Total ash (total inorganic material residue) was determined after igniting of the samples in a muffle furnace at 550°C as described in AOAC [4]. Silica, also referred to as ash insoluble in dilute HCl, was estimated by treating the material with diluted HCl, boiled and filtered through Whatman filter paper, washed and finally ignited and weighing as described by RANJHAN and GOPAL [24]). Calcium contents in crop-residues and concentrate feed samples and magnesium in the concentrate samples were determined after the ash residues were acid digested using acid mixtures and adjusted to an appropriate dilution. The amount of the minerals in the digest was determined at a specific wavelength by Atomic Absorption Spectrophtometry (Varian Model 10/20 Spectra A). Phosphorus content was calorimetrically estimated as described by FISKE and SUBBAROW [10]. Oxalate concentration in crop-residues was estimated by titration with potassium permanganate as per the description of RANJHAN and GOPAL [24].

Seven polled water samples were collected from recognized animal watering points from each of the study sites. The water samples were also subjected to physical and chemical analysis at EHNRI. Prior to analysis, water samples were passed through Whatman filter paper and chemical contents determined in accordance with the procedure described in the ''Standard Methods for Examination of Water and Wastewater'' [3]. Water samples were analyzed for pH using a pH meter, carbonate alkalinity and bicarbonate alkalinity (titration with sulfuric acid), total hardness (EDTA titration), silica (complexing with ammonium molybdate and comparing with picrate standard), sodium and potassium (flame photometer), calcium and magnesium (compleximetric titration with standard EDTA), chloride (titration with silver nitrate), $HCO_3$ (titration with standard HCl to pH end point) and $H_3PO_4$ (Stannous chloride method using spectrophotometer).

# Results

## IN EXTENSIVE TRADITIONAL CATTLE MANAGEMENT SYSTEM

The means values of mineral elements and oxalate contents of crop-residues from Doukem Koticha and Dire study sites are summarized in Table I. The overall mean oxalate content of teff straw (5.271 ± 2.07 g/kg) was by far greater than its respective mean calcium contents (2.91 ± 1.50 g/kg), and the calcium to oxalate ratios was hence computed as less than one (0.67). Other studied straw types, except mixed straw 1, revealed calcium : oxalate ratio less than 2. Higher mean Oxalate levels (5.93 ± 1.93 g/kg) were obtained from teff straw samples from Dukem Koticha than that of Dire (3.50 g/kg). Among the studied crop-residue samples the mixed straw-1 (12.47 g/kg), mixed straw-2 (6.93 g/kg) and Dagussa straw (6.62 g/kg) showed higher levels of Ca while samples of wheat straw revealed the lowest concentration of Ca (0.85 g/kg).

## IN SMALL-SCALE INTENSIVE SHEEP FATTENING FEEDLOTS

Mean values of mineral elements of commercially and traditionally obtained concentrate feeds from Debre Zeit town are presented in Table II. Among the studied concentrate feed samples a lower mean Ca content was obtained in the wheat bran (0.97 g/kg). The mean phosphorus concentration of

| Study site | Feed type (n) | Total Ash | Ca | P | Ash insoluble in HCl | Oxalate | Ca / P | Ca / Oxalate |
|---|---|---|---|---|---|---|---|---|
| | | | | (g/kg of Dry Matter) | | | | |
| **Dukem Koticha** | Teff straw (8) | 95.62 ± 3.41 | 3.04 ± 1.63 | 1.61 ± 0.42 | 64.16 ± 22.35 | 5.93 ± 1.93 | 1.8 | 0.56 |
| | Mixed straw -1 (1) | 105.3 | 12.47 | 0.56 | 21 | 5.98 | 22.3 | 2.09 |
| **Dire** | Teff straw (3) | 110.33 | 2.56 | 0.86 | 83.70 | 3.50 | 2.9 | 0.97 |
| | Wheat straw (2) | 105.80 | 0.85 | 0.60 | 85.85 | 4.01 | 1.4 | 0.41 |
| | Mixed straw -2 (1) | 86.50 | 6.93 | 0.84 | 16 | 3.74 | 8.25 | 1.85 |
| | Dagussa straw (1) | 126.90 | 6.62 | 1.73 | 68 | 3.74 | 3.83 | 1.77 |
| **Dukem Koticha & Dire (overall)** | Teff straw (11) | 99.63 ± 2.75 | 2.91 ± 1.50 | 1.41 ± 0.56 | 69.49 ± 25.83 | 5.27 ± 2.07 | 2.06:1 | 0.67 |

TABLE I. — Mineral and oxalate content (means ± standard deviations) of crop-residues used as cattle feed in Adea district, central Ethiopia.

| Feed type (n) | Total Ash | Ca | P | Mg | Ca:P |
|---|---|---|---|---|---|
| | | (g/kg of Dry Matter) | | | |
| **Wheat bran (3)** | 40.96 | 0.97 | 6.53 | 2.50 | 0.14 |
| **Mixed-grain flour (3)** | 113.50 | 2.82 | 3.49 | 2.63 | 0.86 |
| **Linseed cake (1)** | 83.20 | 4.31 | 6.49 | 4.47 | 0.68 |
| **Mixture of noug and sunflower cake (1)** | 68.80 | 4.79 | 7.67 | 4.56 | 0.62 |

TABLE II. — Mineral values of concentrate feed used for fattening rams in Debre Zeit town.

mixed-grain flour was found to be considerably lower than the other concentrate feeds (3.49 g/kg). With the exception of magnesium, the mineral composition of wheat bran and mixed-grain flour were found to be different.

### WATER ANALYSIS

The mean values of the physical and chemical characteristics of water used for both cattle and sheep are presented in Table III. The electrical conductivity of all the sampled water sources was within the recommended water quality standards (0-800 microsiemens/cm) as suggested by SCHOELLER [28]. The total dissolved solids or salinity, obtained from electrical conductivity data was also found to be within the recommended water quality standard (0-500 mg/l). The pH values of all water samples are alkaline (> 7). With regard to the concentration of mineral elements ($Na^+$, $Ca^{2+}$, $Mg^{2+}$, $Cl^-$, $K^+$, $HCO_3^{2-}$), the values were either below or within the recommended mineral concentration limits for livestock as suggested by EDWARD and others [9]. The recommended mineral concentration limits (ranges) were $Na^+$ (0-115 mg/l), $Ca^{2+}$ (1000 mg/L), $Mg^{2+}$ (250-500 mg/l) and $Cl^-$ (0-180 mg/l), $K^+$ (250-500 mg/l) and $HCO_3^{2-}$ up to 1300 mg/l.

## Discussion

The mean calcium contents of teff straws from Dukem Koticha and Dire study sites were within the suggested requirements of 2-6 g/kg range of ARC [2]. It was, however, found to be relatively lower than to those reported in the other parts of Ethiopia [16, 17, 29]. On the other hand, the wheat straw samples were found to be deficient in calcium. The calcium contents of 'Dagussa' straw and mixed straw-2 (bean, pea and wheat straw) were above the recommended level. Mixed straw-1 ('Guaya', wheat and barley straw) was also found to contain higher levels of calcium. The mean total oxalate content of teff and wheat straws were by far greater than their respective mean calcium contents, hence, the calcium to oxalate ratios were accordingly computed as less than 1. Other studied straw types, except mixed straw-1, revealed calcium : oxalate ratio less than 2. ACKERMAN and GEBAUER [1] suggested that calcium : oxalate ratio in a diet just below the

| Source (n) | Electric Conductivity (µS/cm) | pH | Bicarbonate Alkalinity (mg/l) | Total Hardness (mg/l) | Silica | $Na^+$ | $K^+$ | $Ca^{2+}$ | $Mg^{2+}$ | $Cl^-$ | $HCO_3^{2-}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | (mg/l) | | | |
| **Pond (2)** | 667.73 | 7.7 | 303 | 148 | 76.53 | 97.20 | 11.88 | 35.79 | 14 | 20 | 369 |
| **Stream (2)** | 329 | 8.1 | 170 | 118 | 31.60 | 27.20 | 11.56 | 23.86 | 10.68 | 10.80 | 207 |
| **Tap (2)** | 500.90 | 8.2 | 260 | 222 | 78.60 | 30.60 | 5.94 | 53 | 21.40 | 12 | 317 |
| **Lake (1)** | 435 | 7.5 | 90 | 88 | 11.60 | 47.60 | 9.90 | 25.65 | 5.84 | 76.98 | 109.80 |

TABLE III. — Physical and chemical characteristics of different water sources used for animals in the study areas.

critical value of 2 indicates likely excess in the intake of oxalates. In light of this fact, the results from the present study showed that oxalate content of the studied feedstuff, except mixed straw-1, are regarded as excess. RANJHAN [25] stated that cereal straw in general as poor sources of calcium, and high oxalic acid content in straws limit calcium absorption. RAO [26], on the other hand, indicated that paddy straw feeding be considered as one of the factors involved in the genesis of calculi. It is known that oxalic acid combines with calcium in the body to produce calcium oxalate, which is then stored in the kidneys. WALTER-TOEWS and MEDOWS [31] in their report on urolithiasis in a group of beef cattle, associated oxalate ingestion at 0.36 % DM in the animals feed, also related to low dietary calcium and decreased water intake of animals, hence, serving as a predisposing factor to urolith formation. Similarly, in the present study, it was found that crop-residues commonly used dry season cattle feed; contain excess oxalate and low calcium levels. Added to this is lack of adequate supply of drinking water. Analysis of the composition of urolith samples from cattle of the same area had revealed calcium and oxalate as major constituents [27]. The presence of close relationship between the composition of urolith samples and the mineral contents of the feed used further supports the notion that the identified chemical is the dietary factor which would be involved in urolith formation in cattle in the study areas.

A dietary phosphorus level of 2.5 g/kg is considered sufficient for ruminants [19]. UNDERWOOD [30] suggested a dietary P level of 1.7 g/kg to be marginal for growing ruminants. In the present study, P content of the crop-residues except in the Dagussa straw was lower than these values.

Analysis of the mineral composition of all the concentrate feeds used in the present study showed the presence of higher level of phosphorus as compared with recommended values of 1.5-2.1 g/kg of DM [2]. Although calcium was deficient only in the wheat bran, the calcium : phosphorus ratio was below the minimum requirement (1.2 : 1) in all the studied feedstuff. Additionally, the magnesium content of all the concentrate was above the recommended requirement (1 g/kg DM) as proposed by McDOWELL [19]. The concentrations of phosphorus and magnesium in the mixed-grain flour were relatively lower than commercially available concentrate feeds. Diets containing up to 0.33 % of DM of phosphorus were not indicated to be associated with urolith formation in sheep. It is only when animals were fed at concentration beyond this level that they develop urinary calculi [5]. Similarly, workers in Indiana, South Dakota and Texas confirmed the importance of phosphorus in concentrate feed. They have proved that a low ratio of dietary of calcium to phosphorus result in high phosphorus level in plasma and urine [6, 7, 14, 23]. The recommended range of calcium to phosphorus ratio, to prevent urolithiasis, is 2 : 1 to 2.5 : 1 [13]. Regarding magnesium, CUDDFORD [8] stated that the implication of high level of this mineral (> 2 g/kg DM) as a causal factor of urinary calculosis in concentrate-fed lambs. High concentration of phosphorus, particularly in commercially obtained concentrate feeds, the imbalance in calcium and phosphorus ratio and high concentration of magnesium in the oilseed cakes could, thus, be regarded as the main cause of urolith formation in rams in the study area. This finding is also consistent with the reports of other authors [11, 13].

Different authors studied the importance of inadequate intake and drinking of highly mineralized water as precipitating factor in calculi formation [5, 11, 26]. Drinking water is scarce during most months of the year in the two rural studied sites. This is confirmed as resulting either due to shortage of water or far distant watering points. Analysis of the results of the physical characteristics and mineral contents of drinking water used for the animals in the study areas suggested that the obtained values fall within the recommended normal ranges. Therefore, shortage of drinking water would be ascribed as a precipitating factor in the development of cattle urolithiasis in these areas. This observation is consistent with that of FLOYD [11] who indicated that water deprivation could cause relative concentration of urinary mineral solutes and increases the likelihood of their precipitation. Conversely, water supply was adequate to sheep kept by smallholder sheep farmers in the urban site (Debre Zeit). Under this scenario, drinking water may be regarded as a possible contributing factor to calculi formation in rams, only if it is associated with metabolic disorders that could interfere with intake. This, in turn, may be related with the type of feed the animals are provided. It was known that roughage is provided to these rams on occasional basis. HAY [13] indicated the reduction of water intake and urine volume in animals could result from feeding of concentrate instead of roughage diets. The same author also stated that intermittent feed intake triggers a renal response, which reduces urinary production, thus favoring urinary concentration and precipitation of salts. Ad-libitum feeding will ensure that abrupt change in urinary constituents will not occur. Animals that drink more will excrete more diluted urine, which will tend to reduce the likelihood of calculi formation.

From this study, it would appear that excess oxalate in the commonly used dry season cattle feed, shortage of drinking water and dehydration due to hot weather condition during the long dry season be important factors in cattle urolith formation. Wheat bran and the oilseed cakes were found to contain excess phosphorus and magnesium and hence can be considered as important factors in urolithiasis of rams. Decreased water intake due to lack of regular provision of roughage is anticipated as precipitating factor to urinary caliculosis in sheep. Thus, possible measures to alleviate these constraints should be envisaged. Regarding cattle urolithiasis the use of leguminous straw mainly 'Guaya' (*Lathyrus sativus*) should be encouraged due to its high calcium content and reasonable calcium: oxalate ratio, particularly for cattle at risk to develop urethral obstruction due to urolithiasis. Besides, farmers should be advised to add dicalcium phosphate to the diet of male cattle, particularly during the dry season when the precipitating factors prevail most apparent. Improvement in frequency of water provision to cattle is a priority to all rural sites if the loss from urolithiasis has to be curved. Envisaging various means of reducing oxalate content in crop-residues, particularly in teff straw, is a fertile subject of future researches. Small-holder sheep farming town dwellers should be encouraged to use mixed-grain flour as a fattening ration due to its relatively lower phosphorus content when compared with wheat bran. Provision of roughage to concentrate fed rams should be advised since it stimulates salivary flow, increase water intake and endogenous faecal excretion of phosphorus. To promote water consumption and diuresis addition of sodium chloride up to 4 % of the ration should also be advised to smallholder sheep fattening farmers.

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