

Mineral Composition of Uroliths in Cattle in the Region of Kayseri

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Summary: There are a few reports on quantitative analysis of bovine uroliths in the world's veterinary literature. The aim of the present study was to report the quantitative mineral composition of uroliths found at post mortem in kidneys of cattle in Turkey. In this study, 1840 cattle were examined (1060 male and 780 female). Uroliths were found in 20 of 1.840 animals. These uroliths were obtained from 12 (60%) males and 8 (40%) females. The prevalence was 1.08%. Urolith samples were analyzed by polarizing light microscopy and infrared spectroscopy. Analyses of the 20 uroliths revealed that 11(55%) were composed of magnesium calcium phosphate carbonate, 2 (10%) were magnesium calcium phosphate, 2 (10%) were silica, 1 (5%) was magnesium ammonium phosphate hexahydrate (struvite), 1(5%) was calcium carbonate, 1 (5%) was calcium phosphate compound. One compound urolith was composed of a central portion of calcium carbonate surrounded by a shell of silica. The other compound urolith was composed of a center of 90% calcium phosphate carbonate and 10% struvite, surrounded by a shell of 85% magnesium calcium phosphate carbonate and 15% struvite.

Key Words: Bovine, kidney, quantitative analysis, uroliths

Kayseri Bölgesi Sığırlarında Ürolitlerin Mineral Kompozisyonu

Özet: Dünya veteriner literatüründe sığır ürolitlerin kantitatif analizi ile ilgili az sayıda rapor vardır. Bu çalışmanın amacı, Türkiye'de sığır böbreklerinde post mortem bulunan ürolitlerinin kantitatif mineral bileşimini rapor etmektir. Bu çalışmada, 1.840 tane sığır (1.060 erkek ve 780 dişi) incelendi. Ürolit 1.840 hayvanın 20 tanesinde bulundu. Bu ürolitlerin 12 (% 60)'si erkek, 8 (% 40)'i dişilerden elde edildi. Ürolit prevalansı %1.08 olarak belirlendi. Ürolit örnekleri ışık mikroskobu ve kızılötesi infrared spektroskopisi ile analiz edildi. Tespit edilen 20 ürolitlerin analizleri ile ilişkili olarak, 11 (%55)'i magnezyum kalsiyum fosfat karbonattan, 2 (% 10)'si magnezyum kalsiyum fosfat 2 (% 10)'si silika, 1 (% 5)'i magnezyum amonyum fosfat heksahidrat (struvit), 1 (% 5)'i kalsiyum karbonat, 1 (% 5)'i kalsiyum fosfattan oluştuğu belirlendi. Bir ürolitin bileşimi silika kabuk ile çevrili kalsiyum karbonat merkezli bir bölümden oluştu. Diğer ürolitin bileşimi % 90 kalsiyum fosfat karbonat ve % 10 struvit merkezli ve % 85 magnezyum kalsiyum fosfat karbonat ve % 15 struvit bir kabuk sarılıydı.

Anahtar Kelimeler: Böbrek, kantitatif analiz, sığır, ürolit

Introduction

Urolithiasis is a general term referring to the causes and effects of stones anywhere in the urinary tract including the kidneys and bladder. Nephroliths are uroliths located in renal pelvis and/or collecting diverticula of kidney (17). Nephroliths may be clinically silent, obstruct the renal pelvis or ureter, predispose to pyelonephritis or result in compressive injury to renal parenchyma leading to renal failure (15). Uroliths in cattle, sheep, and goats are common (7, 10, 21, 25, 26, 28, 32). It occurs in both sexes, although obstruction occurs most frequently in males and steers (7, 24). The majority of urolith in cattle is either struvite or silica (3, 8, 10, 35).

Urolith formation usually results from a combination of physiological, nutritional, genetic derangements and management factors. Decreased water intake, urinary stasis, altered urine pH, relative lack of inhibitors of crystallization, urinary tract infection, vitamin A deficiency, and high estrogen intake have all been implicated as risk factors. Urolithiasis is mainly attributed to excessive or imbalanced intake of minerals (9, 16, 22, 24, 26, 27,34). Geographical and seasonal influences play an important role for range herds in semiarid areas (1, 10, 14, 17, 19, 20). The role of water hardness in the development of urolithiasis is controversial (5, 30). Water hardness is defined as the amount of calcium and magnesium found in water and is expressed as the concentration of calcium carbonate (4, 30). Early investigators reported an inverse relationship between drinking water hardness and calcium urolithiasis (6, 31). Animals

that consume additional water will be less likely to form highly concentrated urine and, as a result, urine will contain lower concentrations of calculogenic minerals. This will in turn minimize formation of crystals and uroliths. The simplest way of reducing the supersaturation of urine is to increase the urinary volume (5, 10, 12, 26).

The objectives of this study were to 1) determine the prevalence of uroliths in cattle in Kayseri region, Turkey, 2) the quantitative mineral composition of uroliths, and 3) the effect of water hardness as a possible risk factor in the development of urolithiasis. Based on post mortem evaluation, we hypothesized that a variety of minerals are present in uroliths of cows living in the Kayseri region of Turkey.

Material and Methods

Animals

Only the kidneys of cattle slaughtered in Kayseri (Turkey) were the material of the present study. A total of 1840 cattle were used in this study. Out of 1840 cows, 1060 were male and 780 were female; 738 were Brown Swiss, 660 were Simmental, and 442 were Holstein. Ante mortem examinations of animals were carried out by veterinarians. Postmortem examinations were performed and then kidneys of each animal were obtained for examination.

Diets

The composition of the concentrate mixture feed to animals used in this study was barley, wheat, cottonseed pulp, soybean meal, wheat bran and sunflower meal mixed with straw, corn silage, and mineral-vitamin premixes. The Ca:P ratio was 2:1. Water from the wells sampled in this study was constantly available.

Collection of water samples

Water samples were obtained from 20 different sites in the Kayseri region where the animals were raised. Water samples were transported and analyzed for hardness within 48 hours of collection.

Determination of water hardness

The method described by Egemen (11) was used to determine total hardness of water samples. Total hardness was defined as the sum of calcium and magnesium hardness, in ppm as CaCO_3 .

Urolith Analyses

Urolith analyses were performed at the Minnesota Urolith Center (USA). Mineral composition of uroliths was determined by use of optical crystallography (Olympus BH-2 Polarizing Microscope, Olympus America Corporate, Center Valley, PA 18034) and infrared spectroscopy (AVATAR350, Thermo Electron, Madison, WI 53711) (2, 33).

Statistical analysis

The sex and breed effects on the composition of uroliths were tested by Pearson chi-square.

Results

Cows were brought from 20 different sites within Kayseri region. Antemortem physical examination of 1840 cows revealed no clinical abnormalities. Mean age of the cows was 3.8 ± 1.4 and ranged from 2 to 6 years out of 1840 animals. Only 20 cows (1.1%) had uroliths. Out of 20 cows with uroliths, 12 (60%) were male and 8 (40%) were female, there was no significant sex effect on uroliths ($P > 0.05$, $\chi^2 = 0.047$). Out of 20 cows with uroliths, 9 (45%) were Brown Swiss, 8 (40%) were Simmental, and 3 (15%) were Holstein. There was no statistically significant difference between breeds and uroliths ($P > 0.05$, $\chi^2 = 0.902$).

Examination of the kidneys revealed that the most common macroscopic lesions were medullary cysts, hyperemia, and haemorrhage. Uroliths were usually localized in the calyces and renal pelvis (Figure 1A-D, 2A-B). The shapes and weights of the uroliths varied. Some were large and solid; others were small or sand-like. The surface of the uroliths was either smooth or rough and their colors ranged from yellow to brown (Figure 3A-D).

Analyses of the uroliths retrieved from 20 cows revealed that the minerals of 11 samples were composed of magnesium calcium phosphate carbonate (Figure 3C), two were magnesium calcium phosphate, two silica (Figure 2D) and one magnesium ammonium phosphate hexahydrate (struvite) (Figure 2C). One was calcium carbonate (Figure 3A), one calcium phosphate and two were classified as compound (Figure 3B). One compound of urolith had a nidus of calcium carbonate surrounded by a shell of silica. The other compound of urolith had a nidus of 90% calcium phosphate carbonate and 10% struvite, surrounded by a shell of 85 magnesium calcium phosphate carbonate and 15% struvite.

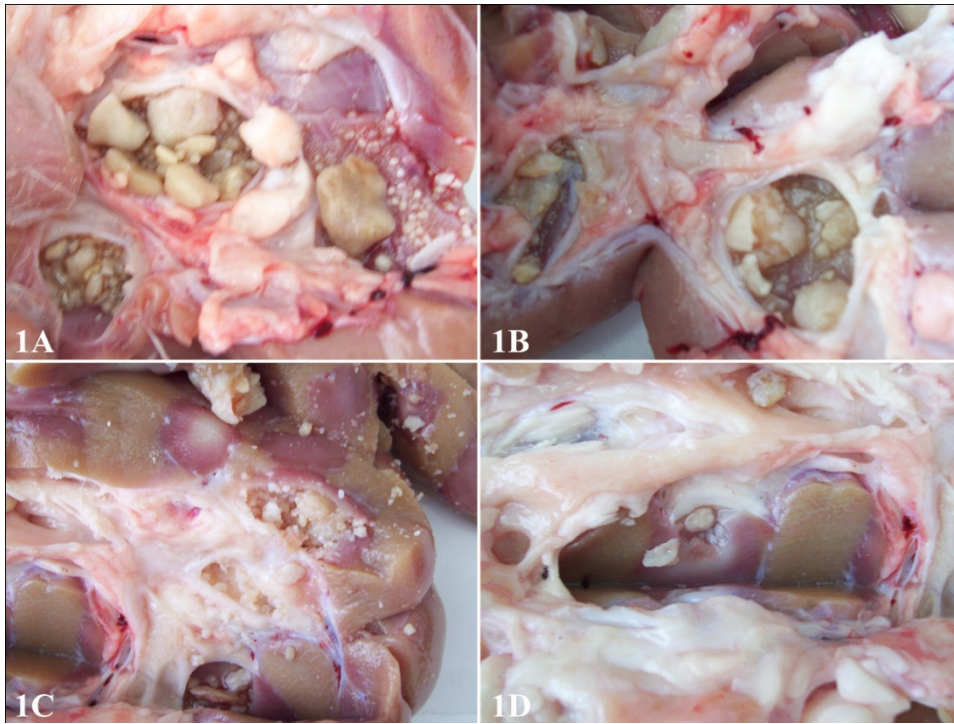


Figure 1. 1A-B: The macroscopic view of uroliths in calix renalis; 1C-D: The stone formation in minor calyces.

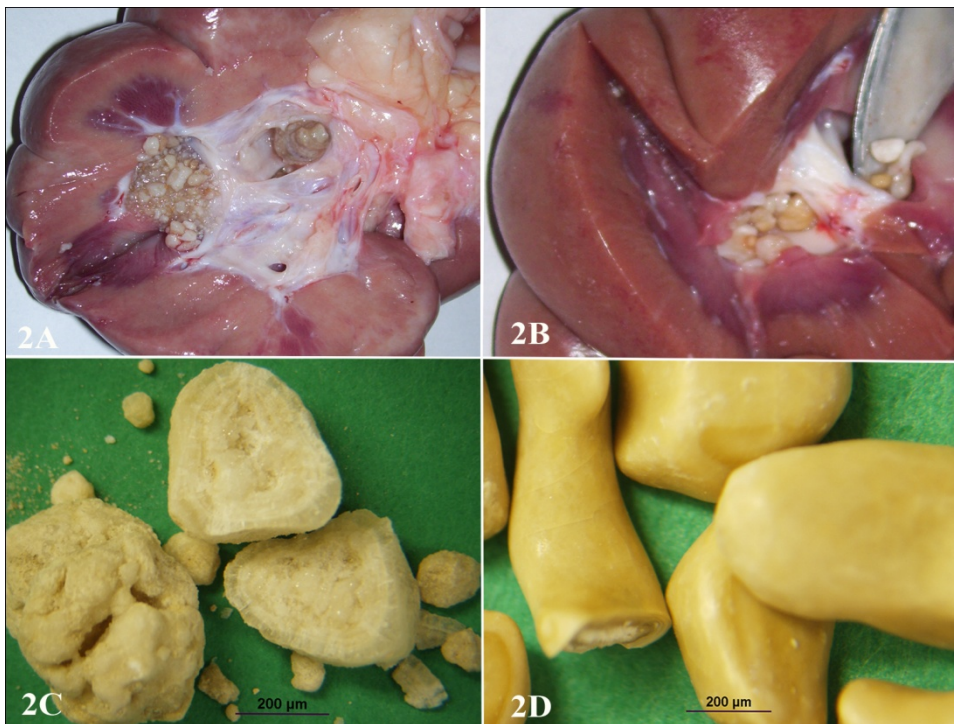


Figure 2. 2A: The appearance of struvite in pelvis renalis 2B: The appearance of silica in pelvis renalis, 2C: The macroscopic view of struvite 2D: The macroscopic view of silica.

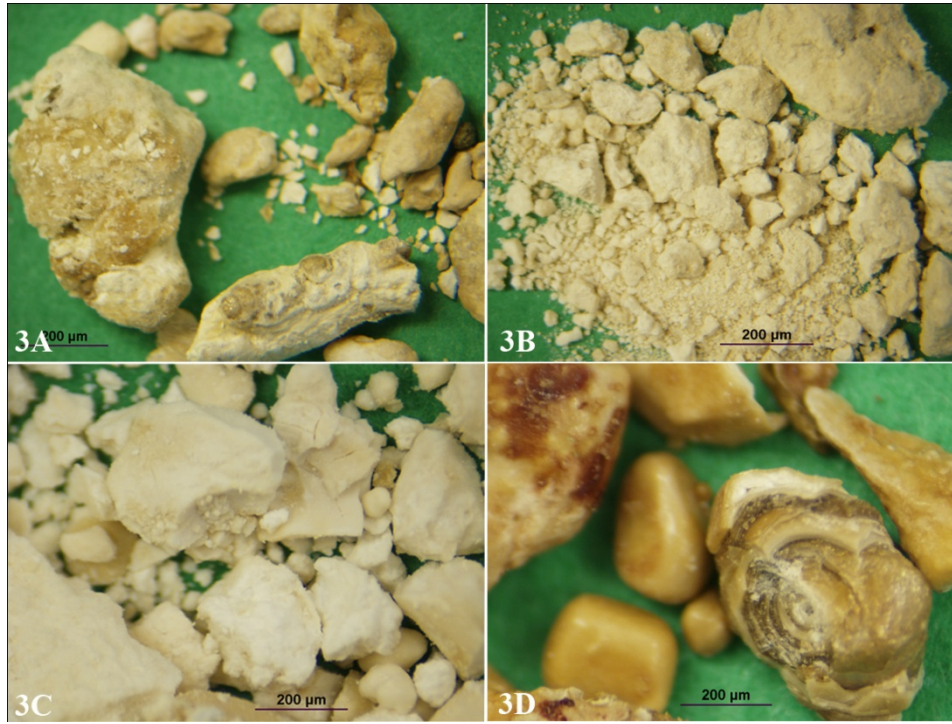


Figure 3. 3A: CaCarb stone, 3B: Compound, 3C: MgCaP Carb, 3D: MgCaP Carb-1

Table 1. Total hardness values from water samples examined in the study

| Localities | Waterhardness (ppm) |
|------------|---------------------|
| Akin | 105.0 |
| Kızık | 92.0 |
| Yazır | 97.5 |
| Hasanarpa | 94.0 |
| Kızılören | 93.5 |
| İncesu | 100.5 |
| Gesi | 170.0 |
| Hanyeri | 81.0 |
| Gelbula | 49.5 |
| Düver | 70.5 |
| Elagöz | 228.5 |
| Erkilet | 100.5 |
| Kuscu | 94.0 |
| Bugdaylı | 202.0 |
| Günesli | 144.5 |
| Yesilyurt | 171.0 |
| Gömec | 130.0 |
| Süksün | 208.0 |
| Mahzemin | 108.5 |
| Akca tepe | 127.0 |
| MV | 123.4 |
| SD | 47.6 |

100 ppm=Acceptable value for water hardness in drinking water (Turkish Codex)

The mean values of total water hardness in water samples are indicated in Table 1. Total water hardness tested in the analysis of all water samples ranged from 49.5 ppm to 228.5 ppm (Table 1). Total hardness in 10 samples exceeded the standards (100 ppm) recommended by Turkish codex.

Discussion

The results of this study are consistent with the hypothesis that a variety of minerals are present in the uroliths of cows. Because of the variety of minerals in the uroliths, it is likely that a variety of risk factors are associated with the formation of bovine uroliths.

Urolithiasis is the most widespread and economically important urinary disease of cows. It is more common in young cows and may reflect both population and feed bias. Disease predominates in late fall or winter and the arid months of summer, likely due to fluctuations in water supply and consumption (24, 27). In the present study, the prevalence of uroliths was 1%, while Gasthuys et al. (17) reported 11.1 %. This could be associated with the different type of feed, water intake, and examination of different urinary tract organs. In this study, only kidneys of cows were examined while bladders and/or urethra of cattle examined in those studies (13,17). Compared to 20.4% prevalence in a previous study (29) from Burdur region of Turkey, the 1% prevalence in the present study was low. This could be explained by different types of feed, water intake, and hardness of water which was reported to be higher than normal in the previous study (29). On the other hand, results of our study indicated that the hardness of water was slightly higher than normal. Hardness of water may play an important role, resulting in different prevalence between the two studies. According to Sahinduran et al. (29), there is a higher concentration of magnesium ions in water. Kallfelz et al. (18) also concluded that feeding rations containing 1.4% magnesium resulted in an increased prevalence of uroliths and urinary tract obstruction in growing male calves. In addition, Medina-Escobedo et al. (23) reported that extreme hardness of water is predisposing factors for development of uroliths in humans.

The higher prevalence of uroliths reported by other investigators (17,23,29) can be explained by the greater values of water hardness. In these regions, dietary risk factors and water hardness may play a major role in mineral composition of nephroliths.

Additionally, results of this study indicated that the types of minerals found in uroliths of cows in Turkey are different from nephroliths found in cows in North America. In the present study, the most common minerals in uroliths was magnesium calcium phosphate carbonate (55%) while struvite (36%) was the most common minerals in cows of North America (25). This may be due, in part, to other risk factors such as types of feed, water intake, and mineral additives.

Conclusion

This pilot study indicates that the prevalence of uroliths in cows living in Kayseri region of Turkey was only 1%. The predominant mineral in nephroliths was MgCaPCarb. Future studies should be designed to evaluate the interrelation of environmental and nutritional factors with the development of uroliths.

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