Influence of water content and the digestibility of pet foods on the water balance of cats

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Abstract

Dietary adjustment has been studied for the control and prevention of the Feline Lower Urinary Tract Disease. This work studied the influence of the amount of water and food digestibility on water intake and excretion (urinary and fecal). Ten adult female cats housed in metabolic cages were used. Four treatments were tested: low price dry food, low price dry food with 50% added water, super-premium dry food and canned food. Water intake with food and by drinking, fecal and urinary water excretion and food's digestibility coefficient were determined, in a Latin square experimental design with repetitions over time. The results were submitted to variance analysis; to Tukey's test to compare means and to Pearson's Correlation to test the association between variables ($p<0.05$). Moist food led to the highest water intake and the largest urine volume with the lowest density. The cats balanced the higher water intake with food by drinking less water. Adding 50% water to the food did not result in a higher total water intake and urine excretion. The lowest consumption of dry matter and highest food digestibility resulted in lower fecal water excretion. Dry foods with high and low digestibility had a urine:feces water excretion rate of 0.7:1 and 1.6:1, respectively. Among the nutrients, fat intake had a positive correlation with the urine volume. Foods with higher digestibility resulted in lower fecal water loss. Canned food (high water:dry matter ratio) led to the highest total water intake and urinary volume excretion, and lower urinary density.

Key-words:
Cats.
Water balance.
Digestibility.
Petfood.
Urine.

Introduction

Dietary adjustments have been widely used in the treatment and prevention of Feline Lower Urinary Tract Disease (FLUTD)[1]. In cases resulting from uroliths - mainly struvite and more recently calcium oxalate - the objective of dietary adjustment is to reduce the urine super-saturation by modifying the urine pH, reducing the intake and excretion of calculogenic substances, as well as increasing the volume of urine.

There is little information available about the correlation between idiopathic cystitis and diet. A clinical study reported an association between feeding cats with dry foods only and the occurrence of idiopathic cystitis[2]. In a prospective study, Markwell et al.[3] found that idiopathic cystitis symptoms recurred in 11% of cats fed moist foods and in 38% of cats fed dry foods. Urine density was the only significant difference found in the comparative urinalysis of both groups, and was lower in the group that was fed moist food. This finding led the authors to suggest urine density as a factor to reduce the recurrence of FLUTD symptoms.

In their review of the diet's effect on non-obstructive FLUTD, Buffington and Chew[1] considered it as important both in relation to crystalluria and to idiopathic cystitis. As increased water consumption dilutes the urine and increases micturition frequency, these authors considered it an important component in the treatment of these two etiologies.

The present study evaluated the effect of four diets with different water contents and digestibility on total water intake; water intake from food; drinking water intake; fecal water excretion and urine excretion of adult female cats.

Materials and Methods

Animals

Ten adult female neutered cats were used. Their average weight was 3.0 ± 0.6 kg and they were considered to be clinically normal based on the physical examination and biochemical analysis. The cats were housed in individual metabolic cages (70 x 70 x 70 cm).

Treatments

Four treatments were tested: an extruded adult cat food with moderate fat and protein levels (food 1 – a commercial low price cat food) in treatment 1 (T1); food 1 with the addition of 50% water in treatment 2 (T2); an extruded super-premium food for adult cats with high fat and protein levels (food 2 - Receita da Natureza® Gatos Adultos, Mogiana Alimentos S. A., Guabi) in treatment 3 (T3); and a commercial canned food for adult cats (food 3 - Top Cat®, Mogiana Alimentos S. A., Guabi) in treatment 4 (T4). Based on their chemical composition, all foods met the nutritional requirements established by the Association of American Feed Control Officials[4] for cats. All four commercial foods used in this study reflect what cat owners commonly use.

Experimental Protocol

Each experimental period had a 10-day duration: 5 days for adaptation and 5 for urine and total feces collection[4]. The cats were fed to meet their caloric requirements expressed by the formula:

Metabolizable energy daily requirement = 60 kcal x (liveweight in kg).

Water and food were provided twice a day. Leftovers were collected and consumption calculated. A blank was used for diets with high moisture level: a sample was left in the environment, out of the cats' reach, and weight loss by evaporation was determined and later subtracted from the moist food leftovers. Feces and urine were collected four times a day and their weight and volume determined, respectively. The material was later stored in a freezer (-14ºC). Urine density was determined using a clinical refractometer and the pH with a pHmeter. The average figures obtained during the 120 hour-collection period (5 days) were used for the analysis.

In the daily balance, water intake from food (WIF), drinking water (DW), metabolic water, total water intake (TWI, obtained by adding the three first items), fecal water excretion (FWE), urinary excretion (UE) and total water excretion (TWE, - the sum of these two last items) were evaluated. The metabolic water (MW) produced by the animals was estimated by multiplying the amount of digestible protein consumed by 0.396, the digestible carbohydrates consumed by 0.566 and the digestible fat consumed by 1.071[1] The difference between TWI and the sum of FWE and UE was computed as insensible losses (IL), corresponding to the sum of losses through the skin, exhaled air and saliva, so as to make the animal's water balance equal to zero.

The protocol to determine the apparent digestibility coefficients followed AAFCO recommendation[4]. After the collection period, the feces were thawed, homogenized, dried at 65°C during 72 h and grinded to 1mm. The chemical analyses of feces and foods, including dry matter, ash, crude protein, acid ether extract and crude fiber, were run in duplicate, according to the methods recommended by the Association of Official Analytical Chemists[5].

Statistical analysis

A Latin Square experimental design with repetitions over time was used with 5 replicates per treatment. This model homogenized individual consumption variations for the various foods, as the test included food with both high and low palatability. The statistical evaluation included normal distribution and variance analyses and Tukey's test ($p<0.05$) to compare averages. The association between variables was determined by calculating Pearson's Correlation using the residues of averages ($p<0.05$). This analysis was performed using the SAS© - System for Elementary Statistical Analysis version 6.12 software[6].

Results and Discussion

Dry matter (DM), organic matter (OM), crude protein (CP), and acid ether extract (AEE) digestibility coefficients were significantly different ($p<0.01$). Food 2 had the best digestibility, followed by food 3, and food 1 ranked as number three. The digestibility effect on the partition of water excreted through feces and urine could thus be evaluated. These data are presented in table 1 along with the foods' chemical composition. No change in the cats' body weight was reported during the test.

During the experiment, DM and OM intakes were not significantly different ($p>0.10$). There was a variation in CP, AEE and nitrogen free extract (NFE) intakes ($p<0.01$); following their amounts in the food, the two first being higher in T3 and T4 and NFE higher in T1 and T2 (Table 2).

Table 2 shows water intake and excretion results as mL per cat per day. These numbers are significantly different ($p<0.05$), indicating an influence of the food's characteristics on the animals' water balance.

The cats' urinary pH was the same in all treatments, ranging from 6.2 to 6.7. Recorded urinary density ($p<0.05$) was lower in T4 (1.043 ± 0.02) than in T1 (1.070 ± 0.01), T2 (1.066 ± 0.02) and T3 (1.080 ± 0.01).

There were major differences in the cats' daily water balance between treatments (Table 2). In this experiment, moist food consumption (T4) resulted in a higher total water intake than described by Smith, Stevenson and Markwell[7] and similar to those found by Seefeldt and Chapman[10], Jackson and Tovey[9] and Gaskell[8]. Values observed for dry foods (T1, T2 and T3) were lower than those reported by Seefeldt and Chapman[10] Jackson and Tovey[9] and Trall and Miller [11]; similar to those reported by Gaskell [7], and higher than those recorded by Lawler and Evans[12]. This finding is in agreement with the latter's statement about the wide variation found in experimental results.

The present results (Table 2) showed that the higher the water content in the food, the higher will be the water intake from food. On the other hand, cats that had the highest water intake from food had the lowest drinking water intake, as seen in T2 that had 50% water added to the food. Total water intake was higher only in T4 ($p<0.001$). Every gram of ingested DM resulted in the intake of 2.4 mL water (TWI) in T1, 2.6 mL in T2, 2.5 mL in T3, and 4.7 mL in T4 (canned food). This relationship showed that the addition of 50% water to the food in T2 did not increase total water intake. It only occurred with the moist food, which had 80% of water (4 g of water per g of dry matter). Anderson[13] had already described this discrepancy between the total water intake of cats consuming moist and dry foods.

There is a discrepancy between the results of this experiment and those reported by Trall and Miller[11], Jackson and Tovey[9], and Seefeldt and Chapman[10], as in their experiments the dry foods led to a higher total water intake. The difference is explained by the lower dry matter intake (DMI) found in the present experiment, as a positive correlation was found between DMI and drinking water ($r=0.70$; $p<0.006$), and DMI and total water intake ($r=0.88$; $p<0.0001$). The lower DMI of the cats in this experiment is probably due to the higher digestibility and metabolizable energy coefficients of the dry

Table 1 - Chemical composition (dry matter base) and apparent digestibility coefficients of the experimental foods (mean ± standard error mean). Jaboticabal, 2003

Food	DM (%)	OM (%)	CP (%)	AEE (%)	NFE (%)
Food 1 composition	92.02	92.62	27.05	6.25	55.91
Digestibility	67.2 ±0.2^{c}	69.1±0.4^{b}	63.9±0.4^{b}	79.4±0.5^{b}	75.4±0.6^{a}
Food 2 composition	96.59	91.84	40.55	19.25	28.32
Digestibility	77.3±0.2^{a}	83.4±0.2^{a}	80.9±0.2^{a}	92.9±0.5^{a}	82.9±0.1^{a}
Food 3 composition	21.09	87.56	45.65	30.32	8.19
Digestibility	72.9±0.3^{b}	78.3±0.3^{a}	77.0±0.4^{a}	90.6±0.3^{a}	45.8±1.2^{b}

DM- dry matter; OM- organic matter; CP- crude protein; AEE- acid ether extract; NFE- nitrogen-free extract.
^{a,b,c} – means in the same column without a common superscript letter differ ($p < 0.05$).
Food 1 – ingredients: poultry-by-product meal, meat and bone meal, fish meal, ground corn, brewer's rice, corn gluten meal, soybean meal, wheat bran, stabilized animal fat, calcium carbonate, sodium chloride, taurine, vitamin and mineral premix.
Food 2 – ingredients: chicken meat, chicken meat meal, rice, fish oil, chicken fat, canola oil, beet pulp, sodium chloride, taurine, vitamin and mineral premix.
Food 3 – ingredients: chicken meat, cattle liver, carrageen, chicken oil, fish meal, water, sodium chloride, taurine, vitamin and mineral premix

Table 2 - Nutrient intake, water intake and water excretion per cat per day according to the experimental treatment (mean ± standard error mean). Jaboticabal, 2003

	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Intake				
DM (g)	48.0 ± 1.2 ^{a}	44.6 ± 1.1 ^{a}	42.8 ± 0.6 ^{a}	33.7 ± 0.4 ^{a}
CP (g)	11.6 ± 1.3 ^{b}	10.7 ± 1.0 ^{b}	17.4 ± 1.3 ^{a}	15.4 ± 0.9 ^{a}
AEE (g)	3.0 ± 0.1 ^{b}	2.8 ± 0.1 ^{b}	8.3 ± 0.1 ^{a}	10.2 ± 0.1^{a}
NFE (g)	28.3 ± 0.7 ^{b}	26.3 ± 0.7 ^{b}	12.1 ± 0.2 ^{a}	2.8 ± 0.0 ^{a}
MM (g)	3.2 ± 0.1 ^{a}	3.3 ± 0.1 ^{a}	3.5 ± 0.0 ^{a}	4.2 ± 0.0 ^{a}
TWI (mL)	115.0 ± 2.4 ^{ab}	114.5 ± 3.5 ^{ab}	105.6 ± 1.3 ^{b}	158.0 ± 1.6 ^{a}
WIF (mL)	4.1 ± 0.1 ^{c}	52.3 ± 1.3 ^{b}	1.5 ± 0.0 ^{c}	126.2 ± 1.5 ^{a}
DWI (mL)	93.5 ± 2.0 ^{a}	45.4 ± 2.0 ^{b}	83.4 ± 1.0 ^{a}	16.8 ± 1.4 ^{b}
MW (mL)	18.2 ± 2.1 ^{a}	16.8 ± 1.8 ^{a}	20.2 ± 1.6 ^{a}	15.6 ± 0.9 ^{a}
Excretion				
TWE (mL)	54.0 ± 1.6 ^{b}	55.3 ± 2.4 ^{ab}	47.0 ± 1.0 ^{b}	91.1 ± 2.3 ^{a}
FWE (mL)	30.6 ± 1.6 ^{a}	34.7 ± 2.2 ^{a}	9.7 ± 0.2 ^{a}	22.6 ± 0.6 ^{a}
UE (mL)	23.4 ± 0.6 ^{b}	20.6 ± 0.3 ^{b}	29.1 ± 0.8 ^{b}	68.5 ± 2.1 ^{a}
IL (mL)	61.8 ± 5.5 ^{a}	59.2 ± 6.1 ^{a}	58.1 ± 6.3 ^{a}	67.6 ± 4.1 ^{a}

DM- dry matter; CP- crude protein; AEE- acid ether extract; NFE- nitrogen-free extracts; MM- mineral matter; TWI- total water intake; WIF- water intake from food; DWI- drinking water intake, MW- metabolizable water; TWE- total water excretion; FWE- fecal water excretion; UE- urine excretion; IL- insensible losses.
^{a,b,c} – means in the same line without a common superscript letter differ ($p < 0.05$)

foods being used, which resulted from the technological advances in production. In relation to excretion, DMI had a positive correlation with fecal water excretion ($r=0.77$; $p<0.0001$), but not with urine excretion ($p>0.19$), demonstrating that the additional water being ingested is lost in the feces, without any advantage for the animal. In average, metabolic water represented 14% of the total water intake.

Total water excretion was higher in T4 as a result of a higher urine excretion (p<0.002), although fecal water excretion was similar to the other groups. The Pearson's correlation indicated that water intake from food was positively correlated with total water excretion (r=0.70; p<0.01), fecal water excretion (r=0.46; p<0.05), and urine excretion (r=0.60; p<0.01). Drinking water was correlated with total water excretion (r=0.72; p<0.01) and fecal water excretion (r=0.88; p<0.01), but not to urine excretion (r=0.14; p>0.5). These data show that the urinary volume is only altered by the increase in food water content, and only when the diet has a high water:dry matter ratio, in agreement with the findings of Seefeldt and Chapman [12] and Gaskel [7], who reported a high water:dry matter ratio equal to or higher than 3.

The higher the DM, OM and NFE digestibility and the lower the DMI, the lower the fecal water excretion (p<0.01). A variable dependent on the digestibility coefficient of food, the percentage of water in the feces had a negative correlation with urine excretion (r = -0.51; p<0.02). Thus, fecal water excretion was lower in T3 as a result of the lower DMI and higher digestibility coefficient found for food 2 (Table 1). The urine excretion: fecal water excretion ratios for the dry foods were 0.8:1 for T1, 0.6:1 for T2, and 1.6:1 for T3, stressing that the digestibility of food interferes with the partition of water excretion between the renal and the intestinal pathways. The data found in this experiment is in agreement with the 1.7:1 and 1.2:1 urine excretion:fecal water excretion ratios for higher and lower digestibility foods, respectively, reported by Trall and Miller [14].

As for the food characteristics, it was found that fat (AEE) intake was positively correlated with urine output (r=0.56; p<0.01) and metabolic water production (r=0.86; p<0.0001). This aspect had three interfering factors: the first related to the high fat digestibility coefficient, ranging from 79.4% for food 1 to 92.9% for food 2 and resulting in a lower elimination of fecal matter; the second related to metabolic water production during oxidation of fat molecules [3]; and the third due to the increased metabolizable energy of the food, resulting in a decrease in DM intake.

Urinary density results were variable, the lowest being found in T4 (p < 0.01), explained by the negative association between the urinary volume and urinary density (r= -0.54; p<0.01), and by the moist food providing the highest total water intake and urine excretion. The values that were found are close to the urinary density figures reported by Markell et al.[3]: 1.040 for cats fed moist foods and usually higher than 1.050 for cats consuming a dry diet.

The mineral matter of the food is a risk factor for FLUTD, specifically for the formation of uroliths[4]. In the present study, the mineral matter intake was statistically the same in all treatments, although numerically higher in T4, the group that had the lowest urinary density, stressing the importance of water intake from food in the dilution and increase of urine volume.

Influência do teor de água e da digestibilidade de alimentos industrializados sobre o balanço hídrico de gatas

Resumo

A modificação dietética tem sido estudada e empregada no controle e prevenção da Doença do Trato Urinário Inferior dos Felinos. Este trabalho estudou a influência do teor de água e da digestibilidade das rações sobre a ingestão, excreção urinária e excreção fecal de água. Utilizaram-se 10 gatas adultas castradas, alojadas em gaiolas metabólicas.Testaram-se quatro tratamentos: ração enlatada; seca super-premium; seca econômica e seca econômica acrescida de 50% de

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água. Determinou-se a ingestão de água via alimento e bebedouro, a excreção de água via fezes e urina e o coeficiente de digestibilidade das rações. Foi empregado um quadrado latino com repetições no tempo. Os resultados foram avaliados por análise de variância seguido pelo teste de Tukey para a comparação de médias e a Correlação de Pearson para se verificar a associação entre variáveis ($p<0,05$). O consumo de ração enlatada proporcionou uma maior ingestão total de água e uma maior excreção de urina, que apresentou menor densidade. Os gatos compensaram a maior ingestão de água alimentar bebendo menos água. Quanto menor a ingestão de matéria seca e maior a digestibilidade do alimento, menor a excreção fecal de água, pois as rações secas de baixa e alta digestibilidade obtiveram, respectivamente, relação excreção de urina:excreção de água fecal de 0,7:1 e 1,6:1. A ingestão de gordura apresentou correlação positiva com o volume urinário. Rações de maior digestibilidade promovem menor perda fecal de água, mas somente a ração enlatada (alta relação água:matéria seca) proporcionou maiores ingestão total de água e volume urinário.

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