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Water Treated by Magnetic Field to Reduce Excess Nitrogen Output

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Abstract

Data suggests that the properties of magnetically treated water are different from those of untreated water. This fact is usually attributed to the weaknesses of intermolecular interactions (hydrogen bonds) and nucleation processes (effect of impurity, frequency and growth of nuclei). Water treatment by magnetic field is an attractive but still controversial issue concerning to animal production.The purpose of the present study was to investigate the effects of water treatment by magnetic field on nitrogen excretion in livestock.There were evaluated milk production, milk composition, blood biochemical profile, blood gas level and nitrogen balance. We found increases in urea blood, urea milk and decreases nitrogen in urine. These effects were attributed due metabolic alkalosis and reduced glutamine metabolism in kidney to Bicarbonate buffer production. We concluded that the treated water by magnetic field provides an effective way to reduce nitrogen animal excretion and contributing to mitigate environmental impact in livestock.

Keywords: blood gas, drinking water, magnetic field, urea blood, urea milk, urea urine

1. Background

The N excretion should be considering the main environmental impact in the livestock.

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The first environmental concern is the volatilization of N in the form of ammonia (NH3) from animal manures. Volatilized ammonia returns to the land or water via rainfall, dry precipitation or direct absorption. Although ammonia may be beneficial as a fertilizer for agricultural fields, the disposal of animal waste becomes a challenge in the intensive livestock because the amount the N excretion of the manure may exceed the capacity of the land to accept is it as a fertilizer. As livestock and poultry units have increased in size, it has become a big problem to the ecosystem.

Most beef cattle are produced in open feedlots and ammonia losses can represent as much as 70% of the N excreted by those cattle. In swine production, typically only 20 percent to 50 percent of the nitrogen consumed is retained in the body, therefore, 50 percent to 80 percent of the nitrogen consumed is excreted into the environment.Nutrient excretion is a result of the inefficiencies associated with digestion and metabolism. Different methods, techniques and dietary strategies to reduce nitrogen excretion have been focused on finding to mitigating environmental impact. Source reduction is the logical starting point to lessen the environmental impact, but more can be accomplished. Therefore, alternative methods to reduce N excretion by poultry, swine or cattle are needed urgently.

The magnetism is widely used in the fields of physics, industry and commerce and its remarkable effects on calcium reactions have been discovered decades (Cho & Lee, 2005; Coey& Cass, 2000), yet in the case of living organisms, the magnetism has not been fully studied, developed and disseminated. Balieiro et al. (2013) observed significantly lower blood pH in dairy cows consuming magnetic water treatment by magnetic field. Therefore the magnetic water treatment can be provides an effective way to reduce nitrogen excretion whereas bicarbonate production is linked to glutamine degradation and nitrogen excretion. The purpose of the present study is to investigate the effects of water treatment by magnetic field on N excretion in livestock.

2. **Methods**

This research was carried out at the São Paulo State Agency Agribusiness Technology, Secretary of Agriculture and Food Supply, (APTA-SAA-SP), Department of Basic Science and Department of Veterinary Pathology, São Paulo State University (UNESP), SP - Brazil.Were carried out experiments both, ruminants (Experiment 1) and non-ruminants (Experiment 2) digestion process.

2.1. Experiment 01

The cows had an initial weight of 370 kg with more than 100 days breeding. The cows were kept in Tanzania grass throughout the entire experiment manure in crop-pasture rotation. The diet was balance according NRC (1989) were requirements expressed as crude protein. The forage composition was dry matter 21%, crude protein 13.5%, total digestible nutrient 57%, Ca 0.49%, P 0.29%, ether extract 1.9%, neutron detergent fiber 69.3 and neutron detergent acid 34.1%. The cows received 6 kg of ration a day with dry base chemical composition content crude protein 16.44, total digestible nutrient 79.80, Ca 0.56 and P 0.40. The average water intake was 37 l/day.

Twenty six Jersey cows were allotted into two groups: control (n=13) and group drinking treated water by magnetic field (n=13) for 75 days to compare the milk production, milk composition, blood gas level, biochemical profile and serum triglycerides concentration. The magnetic treatment of water was performed using a commercial magnetic conditioner (Sylocimol) designed to generate a strong magnetic monopole field. These devices were inserted into the water troughs (1,500 L), producing a static magnetic field of 32,400 Gauss. Blood samples were collected by arterial (caudal auricular artery) and venous (mammary vein). A completely randomized design was used.

The tests were conducted from late January until April, 2012. A paired t-test was used to determine whether there were significant differences between the two treatments. The null hypothesis is that the difference in the mean values is zero, (H0:mA-mB=0). The trapping data was analyzed with ANOVA using Proc GLM (SAS Institute 1985) with Tukey's mean separation test (*P* = 0.10) used for significant factors.

2.2. Experiment 02

Forty-eight male Wistarrats were divided into two groups: control (n=24) and group consuming magnetic water (n=24). Then, these groups were subdivided into three smaller groups (n=16) and paired by body weight to evaluate three consumption periods (15, 30 and 45 days) in eight replicates. A completely randomized design with two treatments distributed to a 2x3 factorial arrangement was used.

The rats were separated into individual cages. The groups were fed with the same ration during the experiment (Table 1). The treatment of water was performed using a commercial magnetic conditioner (Sylocimol) designed to generate a strong magnetic monopole field of 32,000 Gauss. The rats were kept in individual steel metabolic cages throughout the entire experiment. These devices were inserted into the water troughs of the metabolic cages. The animals had an initial weight of 286g and 357g to 390g for the finishing ones. The animals were randomly assigned to individual steel metabolism cages, equipped with stainless steel feeders and individual troughs. The average room temperature during the trial ranged between 22.8 ± 1.0^{o}C (minimum) and 29.2 ± 2.4^{o}C (maximum). The body weight gain (BWG) and metabolic weight (kg$^{0.75}$), water and dry matter intake (WI, DMI), nitrogen balance and digestibility were observed to isolate the effects of the water treatment by magnetic field. The rats were adapted to cages and in the last 7 days of the period, total fecal and urine collection followed. At the end of each period, blood samples were collected from the femoral artery for blood gas and biochemical profile analysis.

The tests were conducted from late September until early November, 2013. A paired t-test was used to determine whether there were significant differences between the two treatments. The null hypothesis is that the difference in the mean values is zero, (H0:mA-mB=0). The trapping data was analyzed with two-way ANOVA (factors: periods (3 levels) and kinds of water (2 levels)) using Proc GLM (SAS Institute 1985) with Tukey's mean separation test (P = 0.10) used for significant factors.

Table 1: Chemical Composition of Rat's Ration on a Dry Matter Basis

Nutrient	Unit	Level	Nutrient	Unit	Level
Drymatter	g/kg	870	Vitamin A	UI/kg	25,500
CrudeProtein	g/kg	230	Vitamin D3	UI/kg	4,000
Etherextract	g/kg	40	Vitamin E	UI/kg	82
CrudeFiber	g/kg	50	Vitamin K3	mg/kg	6.4
Mineral matter	g/kg	100	Vitamin B1	mg/kg	11
Calcium	g/kg	12	Vitamin B2	mg/kg	12
Phosphorus	mg/kg	8500	Niacin	mg/kg	219
Sodium	mg/kg	2,700	Pantothenicacid	mg/kg	90
Magnesium	mg/kg	500	Vitamin B6	mg/kg	11
Iron	mg/kg	180	Folicacid	mg/kg	12
Copper	mg/kg	30	Biotin	mg/kg	0.16
Manganese	mg/kg	110	Vitamin B12	mcg/kg	40
Zinc	mg/kg	110	Choline	mg/kg	1,800
Iod	mg/kg	1	Lysine	g/kg	12.50
Cobalt	mg/kg	2	Methionine	mg/kg	3,500
Selenium	mg/kg	0,20			

Table 2: Chemical Composition of the Water Treatment by Magnetic Field

	Unit	Treatments Control	Magnetic
Sodium	mg/L	3.0	3.3
Calcium	mg/L	6.8	7.0
Magnesium	mg/L	2.6	2.6
Total hardness	mg/L	30	20
Turbidity	NTU*	0.88	0.14
pH "in situ"		6.90	7.31
Total alkalinity	mg/L	46	45
Carbonatealkalinity	mg/L	0	0
Total residual chlorine	mg/L	0.01	0.01
Total chlorine	mg/L	0.02	0.01
Dissolvedoxygen	mg/L	3.45	4.60
Iron	mg/L	<0.01	<0.01
Solubleiron	mg/L	<0.01	<0.01
Fluoride	mg/L	0.27	0.23
Chloride	mg/L	1.5	1.0
Sulfhate	mg/L	1.0	1.0
Nitrate as NO_3	mg/L	<0.15	<0.15
Nitrate as N	mg/L	0.2	0.2
Nitrite as NO_2	mg/L	<0.001	<0.001

*NTU = nephelometric turbidity units.

2.3. Experiment 01 and 02

The water's chemical composition was analyzed according to APHA (2005) and the dissolved oxygen was analyzed according to the Winkler Method (Table 2).

A blood sampling kit was used for blood gas analysis (3 ml ventilated syringes with 23 G l in a needle, containing freeze-dried lithium heparin), according to Fisher et al. (1980). These samples were immediately analyzed in a calibrated blood gas analyzer set at the body temperature of rats or cows. The samples in tubes with or without EDTA were centrifuged at 1000 rpm 5 and 10 minutes to get plasma and serum, respectively, poured into a clean tube through the pipette. Serum samples were stored at -20ºC until analysis. The chemical tests were performed using commercial test kits (LabtestDiagnóstica S.A. Brazil) and the reader used was a semiautomatic spectrophotometer (LabquestDiagnóstica) in wavelength specific for each blood components.

3. Results

No significant difference was found on daily milk yield (Table 3). However, higher urea content was found in milk of cows drinking treated water by magnetic field compared to control group.

Table 3: Magnetic Treatment of Water on Milk Production

	Control	Test	CV	MSE	Pr>F
Daily Milk Yield (kg/cow)	10.30	11.40	21.14	2.309	0.357
Fat (%)	4.18	4.28	19.88	0.858	0.344
Protein (%)	3.99^b	4.08^a	3.65	0.147	0.019
Urea (mg/dL)	**12.42^b**	**15.67^a**	**8.87**	**1.307**	**<.0001**
Lactose (%)	4.12	4.20	5.31	0.222	0.450
Total solids (%)	13.32	13.72	9.72	1.315	0.445
Casein (%)	3.02^b	3.10^a	4.06	0.124	0.009
CCS (Thousand/mL)	1222	1073	151.5	1411	0.400

Means not bearing the same superscript letters within rows are significantly different ($P>0.05$)

No significant difference was found on CHCO$_3$ in arterial blood (Table 4). However, higher pH and lower pCO$_2$ levels were found in arterial blood of cows drinking treated water by magnetic field compared to control group. As carbon dioxin is higher in venous blood, the effects of the treated water change. No significant difference was found on pH in venous blood (Table 4). However, lower CHCO$_3$ and higher SO$_2$ levels were found in venous blood of cows drinking treated water by magnetic field compared to control group. In both, arterial and venous blood, lower Na was associated with lower osmolality in group drinking treated water compared to control group. The treatment water by magnetic field provides greater metabolic efficiency in removing carbon dioxin, increasing the pH of blood.

Table 4: Magnetic Treatment of Water on Blood Gas Level

	Control	**Test**	**CV**	**MSE**	**Pr>F**
	Arterial Blood				
CHCO$_3$ (mmol/L)	26.14	25.87	4.776	1.231	0.208
SO$_2$(%)	98.44	98.34	0.512	0.503	0.630
BE (mmol/L)	2.80^a	1.77^b	40.70	0.923	0.035
Anion Gap (mmol/L)	15.92	15.88	5.124	0.818	0.694
Osmolality (mOsm/kg)	280.1^a	273.3^b	1.45	4.03	0.0007
PHt	7.41^b	7.45^a	0.28	0.02	0.0004
pO$_{2t}$(mmHg)	101.48	110.43	18.72	19.83	0.326
pCO$_{2t}$(mmHg)	42.47^a	37.97^b	7.58	3.05	0.002
Na (mmol/L)	141.10^a	136.97^b	1.55	2.16	0.0002
Cl (mmol/L)	101.89	99.25	1.95	1.96	0.0161
Ica	1.15	1.19	4.86	0.057	0.122
	VenousBlood				
CHCO$_3$ (mmol/L)	28.54^a	24.28^b	6.04	1.415	0.011
SO$_2$ (%)	72.58^b	82.78^a	2.29	0.791	<.0001
BE (mmol/L)	3.64^a	0.54^b	7.32	1.206	0.004
Anion Gap (mmol/L)	14.44	15.72	6.81	0.719	0.562
Osmolality (mOsm/kg)	275.62	270.50	1.22	5.04	0.087
PHt	7.39	7.40	0.38	0.029	0.462
pO$_{2t}$(mmHg)	39.88	49.56	12.40	11.61	0.223
pCO$_{2t}$(mmHg)	46.70^a	41.16^b	6.29	1.35	0.005
Na (mmol/L)	138.22	135.68	1.31	1.26	0.089
Cl (mmol/L)	98.96	98.94	1.68	1.63	0.288
iCa (mg/dL)	1.11	1.18	5.86	0.063	0.140

Means not bearing the same superscript letters within rows are significantly different ($P>0.05$)

Higher urea level was found in blood of cows drinking treated water by magnetic field compared to control group (Table 5).The results of the tests about Na, BE and osmolality were not always straightforward, which often makes them challenging to interpret and explain, because we didn’t measure individual water intake, dry matter intake, dry matter digestibility or nitrogen urine in cows, so this data is not enough to take a nitrogen balance. However, the results show us increased nitrogen as urea in milk (Table 3) and nitrogen as urea in blood (Table 5) and these effects are coherent with decreased carbon dioxide and consequently increased the pH in arterial blood (Table 4), as much as the decreased of the $CHCO_3$ in venous blood with the same pH (Table 4), whereas both indicate alkalosis effect. The Bicarbonate buffer ($CHCO_3$) formed in the kidneys is transported across a membrane to the extracellular fluid, where it restores blood Bicarbonate that was neutralized by systemic metabolic acid production. The Bicarbonate reduction points to less acid to be neutralized. On the other hand, when no difference was found in Bicarbonate buffer, the blood pH value increased in animals drinking treated water by magnetic field. The rate of renal Bicarbonate and Ammonium production is regulated in response to changes in systemic acid-base status and decreases during metabolic alkalosis. Therefore occurs increases in both, blood and milk urea.

Table 5: Magnetic Treatment of Water on Blood Biochemical Profile

	Control	**Test**	**CV**	**MSE**	**Pr>F**
Urea (mg/dL)	**29.600^b**	**36.200^a**	**20.78**	**7.345**	**0.002**
Glicose (mg/dL)	51.833	52.300	11.45	5.963	0.977
Ca (mg/dL)	9.420	11.233	34.38	3.445	0.265
P (mg/dL)	7.406	5.753	34.76	2.176	0.060
K (mmol/L)	4.573	4.600	15.78	0.733	0.738
Na (mmol/L)	142.66	147.06	4.88	7.062	0.235
Mg (mg/dL)	2.520	2.380	35.70	0.841	0.533

Means not bearing the same superscript letters within rows are significantly different ($P>0.05$)

In metabolic cages was possible have to control, measured and analyses urine and feces, allowing get nitrogen balance. There was no significant interaction between the water and the consumption period on dry matter and water intake, digestibility and N balance ($p>0.05$). There were significant differences regarding the reduction of weight gain of rats drinking the water treated by magnetic field (Table 6).

This effect is in agreement with several authors. Lin e Yotvat (1989) and Levy et al. (1990) observed lower levels of fat in the meat of calves which consumed water treatment by magnetic field. In addition, Patterson &Chestnutt (1993) observed reduction in dry matter intake and a less efficient conversion of food to carcass weight gain of lambs and Balieiro et al. (2013) observed significantly lower on subcutaneous fat thickness in dairy cows consuming magnetic water treatment by magnetic field. On the other hand, Al-Mufarrej et al. (2005) not observe any differences in carcass composition of broilers consuming the water treatment by magnetic field andSargolzehi et al. (2009) did not find significant differences on ions and metabolites of the lamb's blood.

Dry matter intake, water intake, nitrogen intake, urine volume and nitrogen excretion in feces were equal between the groups. Nitrogen balance was positive in both groups, but N retention by body weightwere elevated in rats drinking treated water, probably resulting from decreased nitrogen excretion in urine (Table 6).The ammonium excreted in the urine is produced in the kidney where glutamine is metabolized to form ammonium ions and bicarbonate (Good, 1989). This data points to normal digestion of food proteins, but also points to changes in renal ammonium excretion in systemic pH regulation.

Table 6: Water treated by magnetic field on dry matter intake (DMI), water intake (WI), body weight gain (BWG), Urine Volume, Dry Matter Digestibility (DMD), N intake (NI),N excretedin the feces (NF), N Absorption (NA), NA in % of NI (NANI), N excreted in the urine (NU), N retention (NR), N retention /kg BWGand N retention /kg BWG$^{0.75}$(NR/BWG, NR/BWG$^{0.75}$), Urinary N concentration (UN), Feces N (UF) concentrationand plasma urea concentration (UREA)

	Control	Test	CV	MSE	Pr> F
Inicial BW (g)	287.69	286.64	7.26	20.86	0.927
Final BW (g)	**390.80**^{a}	**357.53**^{b}	**8.41**	**31.49**	**0.071**
BWG (g/day)	**2.291**^{a}	**1.575**^{b}	**27.50**	**0.531**	**0.026**
DMI (g/day)	25.66	24.35	17.38	4.34	0.646
WI (ml)	35.14	32.51	16.90	5.72	0.487
Urine volume (ml)	19.12	18.02	15.02	2.79	0.551
DMD (%)	60.35	61.31	7.46	4.54	0.746
NI (g/day)	0.944	0.896	17.34	0.15	0.647
NF (g/day)	0.262	0.234	43.98	0.10	0.695
NA (g/day)	0.682	0.661	9.28	0.06	0.608
NANI (%)	72.24	73.77	9.49	7.01	0.812
NU (g/day)	0.054	0.056	18.63	0.01	0.765
NR	0.626	0.606	8.73	0.05	0.561
NR/BW (g/kg)	**1.534**^{a}	**1.692**^{b}	**4.84**	**0.07**	**0.012**
NR/BW$^{0.75}$ **(g/kg)**	**6.888**^{a}	**7.350**^{b}	**5.13**	**0.36**	**0.080**
UN (g/kg)	**40.12**^{b}	**37.08**^{a}	**14.87**	**5.732**	**0.092**
UF (g/kg)	38.20	38.20	17.17	6.56	1.000
UREA (mg/dL)	54.85	53.83	9.53	5.18	0.729

Means not bearing the same superscript letters within rows are significantly different ($P>0.05$)

There was no significant interaction between the water and the consumption period on biochemical profile and blood gas level ($p>0.05$).There were two unusual reductions of $CHCO_3$ and CO_2 with the same pH and an increase in Anion Gap in the arterial blood of the rats drinking the water treated by magnetic field (Table 7).As in cows, the bicarbonate formed in the kidneys is transported across a membrane to the extracellular fluid, where it restores blood bicarbonate that was neutralized by systemic metabolic acid production. The bicarbonate reduction is associated with ammonium excretion due the metabolism from glutamine (Good, 1989).

The Hydrogen ion is not accounted for on the cation side in the Anion Gap (cations minus anions), but the decrease in Bicarbonate buffer compensation would appear as a Bicarbonate deficit, and the Anion Gap increased. The reduction of the Hydrogen ions may favor the nitrogen retention thereby reducing glutamine degradationto form bicarbonate (Table 7).

Table 7: Magnetic Treatment of Water on Biochemical Profile and Blood Gas Level

	Control	Test	CV	MSE	Pr>F
Na (mmol/L)	139.96	139.37	2.08	2.913	0.720
K (mmol/L)	4.007	4.005	18.07	0.724	0.996
iCa	**1.288^b**	**1.339^a**	**3.433**	**0.045**	**0.066**
pH	7.32	7.31	0.545	0.039	0.697
pO$_2$(mmHg)	**69.38^b**	**86.02^a**	**16.77**	**13.14**	**0.043**
pCO$_2$(mmHg)	**53.85^a**	**46.40^b**	**15.284**	**7.624**	**0.081**
pHt	7.29	7.28	0.546	0.039	0.572
pO$_{2t}$(mmHg)	**77.33^b**	**96.87^a**	**16.42**	**14.43**	**0.033**
pCO$_{2t}$(mmHg)	60.11	51.73^b	15.32	8.52	0.080
SO$_2$ (%)	**91.75^b**	**94.60^a**	**2.593**	**2.419**	**0.057**
tHb (g/dL)	17.66	15.91	12.17	2.036	0.150
Hct (%)	53.05	47.68	12.16	6.103	0.142
CHCO$_3$(mmol/L)	**28.66^a**	**25.04^b**	**11.08**	**2.962**	**0.050**
ctCO$_2$ (mmol/L)	24.63	22.01	11.78	2.735	0.113
Osmolality (mOsm/kg)	278.8	277.7	1.941	5.402	0.734
Cl (mmol/L)	101.10	102.07	1.876	1.907	0.404
Ânion Gap (mmol/L)	**14.70^b**	**16.95^a**	**10.65**	**1.705**	**0.047**

Means not bearing the same superscript letters within rows are significantly different ($P>0.05$)

4. Conclusion

We concluded that the treated water by magnetic field provides an effective way to reduce nitrogen animal excretion and contributing to mitigate environmental impact in livestock.

5. References

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