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Water Treated by Magnetic Field Increases Bone Mineral Density of Rats

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ABSTRACT:

Background: 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 human health. We found that there were increases in bone mineral density of rats consuming water conditioned by a magnetic field compared to group consuming unconditioned water and this effect may reduce the risk of osteoporosis and bone fractures in humans.

Objective: The purpose of the present study is to investigate the effects of water treatment by magnetic field on Bone Mineral Density (BMD, g/cm^2), Bone Mineral Content (BMC, g), Bone Area (BA, cm^2), Bone Resistance (BR, kN/m), Blood Gas Analysis (Bicarbonate, mmol/L; Anion Gap, mOsm/kg), Blood Viscosity and Blood Biochemical Profile of rats.

Methods: The treatment of water was performed using some commercial magnetic conditioners (Sylocimol) designed to generate a strong magnetic monopole field. These devices were inserted into the water troughs of the metabolic cages. A completely randomized design distributed to a 2x3 factorial arrangement was used. Forty-eight male Wistar rats were divided into two groups: control (n=24) and group consuming magnetic water (n=24). Then, these groups were subdivided into three smaller groups to evaluate three consumption periods (15, 30 and 45 days). The animals were kept in metabolic cages throughout the entire experiment. The BMD, BMC and BA of the right femur were measured by the DPX-Alpha, Lunar® densitometer. BR of the mid shaft and head femoral were measured by the Universal Test Machine EMIC®, DL3000. Blood

samples were collected from the femoral artery using a blood sampling kit for blood gas analysis (3 ml ventilated syringes with 23 G l in needle, containing freeze-dried lithium heparin). All the samples were immediately analyzed in a calibrated blood gas analyzer set at the body temperature of rats.

Results: No significant differences were found on water intake (35.14 vs 32.51, $p>0.05$), dry matter intake (25.66 vs 24.35, $p>0.05$), BA (1.29 vs 1.29 cm^2) or head femoral resistance (95.56 vs 102.48 kN/m). However, higher Anion Gap (14.70 vs 16.95 mOsm/kg, $p<0.05$) and lower $CHCO_3$ (28.66 vs 25.04 mmol/L, $p<0.05$) were found in arterial blood of the group drinking treated water. There was significant interaction between water and consumption period on BR, BMD and BMC ($p<0.05$). In the first analysis (after fifty days), there was no difference ($p<0.05$) in BMC and BR between the two groups. In the second evaluation (after thirty days), there were increases in BR (mid shaft), BMD and BMC ($p<0.05$). After forty-five days, there were increases in BR, BMD and BMC ($p<0.05$) and the differences between the groups were bigger.

Conclusion: The treated water intake for more than 45 days can reduce the risk of osteoporosis and fractures by reducing hydrogen competition for calcium binding sites and increased bone mass.

Keywords: blood biochemical, blood gas, blood viscosity, bone mineral density, drinking water, magnetic field

BACKGROUND:

The magnetism is widely used in the fields of physics, industry and commerce and its remarkable effects on calcium reactions have been discovered decades [6, 7], yet in the case of living organisms, the magnetism has not been fully studied, developed and disseminated. On the other hand, osteoporosis is a significant health problem all over the world and in recent years, the issue of low bone mass/low bone density in children and adolescents has attracted much attention. Whereas calcium is a major structural element in bones and is a key player to bone health, calcium absorption and higher iCa favors a better bone densitometry. According to Good (1989) the reduction of the hydrogen ions may favor the bone densitometry thereby reducing competition for calcium binding sites. In addition 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 improve bone mineral content and to reduce the risk of osteoporosis and the bone fractures by reducing hydrogen competition for calcium binding sites.

There are many causes and many connections between blood gas, biochemical profile, viscosity and others parameters that help to elucidate the mechanisms that resulting in effects of the magnetic water treatment on bone densitometry. Osteopenia and osteoporosis are no longer exclusively the concern of adults and older people, since the bone mineral density of these age groups is dependent upon the peak bone mass acquired by the end of the second decade of life [3]. In addition from the age of 50 onwards, 30% of women and 13% of men may suffer some type of fracture [1]. The incidence of fractures will quadruple over the next 50 years as a result of increased life-expectancy [2].

The purpose of the present study was to investigate the effects of consumption of the water treated by magnetic field on Bone Mineral Density (BMD, g/cm2), Bone Mineral Content (BMC, g), Bone Area (BA, cm2), Bone Resistance (BR, kN/m), Blood Gas Analysis (Bicarbonate, mmol/L; Anion Gap, mOsm/kg), Blood Viscosity and Blood Biochemical Profile of rats.

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.

Forty-eight male Wistar rats 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 2 x 3 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. These devices were inserted into the water troughs of the metabolic cages. The water's chemical composition was analyzed according to APHA (2005) and the dissolved oxygen was analyzed according to the Winkler Method (Table 2).

The rats were kept in individual steel metabolic cages throughout the entire experiment. 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. 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. 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 (Labtest Diagnóstica S.A. Brazil) and the reader used was a semiautomatic spectrophotometer (Labquest Diagnóstica) in wavelength specific for each blood components. The blood collected in 10 mL tube with anticoagulant K_2EDTA was processed to obtain hematological parameters.

Arterial blood viscosity was measured within 1 h from blood withdrawal; the blood specimen was added with heparin (35 U.I./mL). Blood viscosity was evaluated at shear rates of 225 (η225) s−1. A 0.5 mL aliquot was used to determine the sheer force (shear stress SS, N / m 2) under the sheer rate (shear rate, SR, s-1) corresponding to 60 rpm. Viscosity measurement was performed at 37 °C with a cone-plate viscometer (Wells-Brookfield DV-III, Stoughton, USA) equipped with a CP-40 spindle. The determinations were carried out in buffer (for each run) and in the samples at intervals of one minute between speed increments, with 30 plus seconds of stabilization.

The Bone Mineral Density (BMD, g/cm2), Bone Mineral Content (BMC, g) and Bone Area (BA, cm2) of the right femur were measured by the DPX-Alpha, Lunar® densitometer. Bone Resistance (BR, kN/m) of the mid shaft and the head femoral were measured by the Universal Test Machine EMIC®, DL3000.

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 ration on a dry matter basis.

Nutrient	Unit	Level	Nutrient	Unit	Level
Dry matter	g/kg	870	Vitamin A	UI/kg	25,500
Crude Protein	g/kg	230	Vitamin D3	UI/kg	4,000
Ether extract	g/kg	40	Vitamin E	UI/kg	82
Crude Fiber	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	Pantothenic acid	mg/kg	90
Magnesium	mg/kg	500	Vitamin B6	mg/kg	11
Iron	mg/kg	180	Folic acid	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

		Treatments	
	Unit	**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
Carbonate alkalinity	mg/L	0	0
Total residual chlorine	mg/L	0.01	0.01
Total chlorine	mg/L	0.02	0.01
Dissolved oxygen	mg/L	3.45	4.60
Iron	mg/L	<0.01	<0.01
Soluble iron	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.

Results:

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 3). 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 and Sargolzehi et al. (2009) did not find significant differences on ions and metabolites of the lamb's blood.

Every hypothesis has been tested experimentally, but does not fully explain all the accumulated data. The lowest weight gain and fat reduction may be mainly due to the increased solubility of calcium and increased lipid metabolism enzymes. It is known that calcium intake is mainly absorbed by active transport in the upper small intestine, so movement against a concentration gradient of energy is necessary, being a process which requires an additional energy source. In addition, the calcium ion, which implies a greater willingness for the needs of the organism to play important roles, such as its junction with the calmudulina causes it to activate, allowing stimulation of a large number of enzymes; as all enzymes of lipid metabolism (regulatory lipase by AMPc), are responsible for the ionic permeability of the cells, the synthesis of neurotransmitters and their release, and reporter enzymes of glycogen metabolism (glycogen phosphorylase). That is, it promoted the breakdown of molecules to release free energies in the body, and the consumption of such energy in the synthesis of other molecules.

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 weight were elevated in rats drinking treated water, probably resulting from decreased nitrogen excretion in urine (Table 3). The ammonium excreted in the urine is produced in the kidney where glutamine is metabolized to form ammonium ions and bicarbonate. This data points to normal digestion of food proteins, but also points to changes in renal ammonium excretion in systemic pH regulation.

Table 3 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 excreted in the feces (NF), N Absorption (NA), NA in % of NI (NANI), N excreted in the urine (NU), N retention (NR), N retention / kg BWG and N retention / kg $BWG^{0.75}$ (NR/BWG, $NR/BWG^{0.75}$), Urinary N concentration (UN), Feces N (UF) concentration and 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**	**357.53**	**8.41**	**31.49**	**0.071**
BWG (g/day)	**2.291**	**1.575**	**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**	**1.692**	**4.84**	**0.07**	**0.012**
NR/BW$^{0.75}$ (g/kg)	**6.888**	**7.350**	**5.13**	**0.36**	**0.080**
UN (g/kg)	**40.12**	**37.08**	**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

There was no significant interaction between the water and the consumption period on viscosity, biochemical profile and blood gas level ($p>0.05$). The overall viscosity of whole blood, increased as the percentage of cells in the plasma increases, mainly due the red blood cells. Although there was no significant effect on hematocrit, hemoglobin or viscosity, the viscosity dropped from 2.68 to 2.18cP, reduce by 17.1%, was consistent with the reductions of the hematocrit (53.05 to 47.68%) and the hemoglobin (17.66 to 15.91g/dL) (Table 4). The hemoglobin values were in the normal range for men (14 to 18g/dL) and the hemoglobin reduce by 10%, was consistent with the significant rises on oxygen saturation (91.75 to 94.60) (Table 4). It has been generally accepted that red cells are paramagnetic with a magnetic susceptibility, since the hemoglobin in red blood cells is an iron containing protein capable of binding oxygen molecules. Therefore, a strong magnetic field induces dipolar interaction, which aggregates red cells clusters have a streamlined shape that favors the flow dynamics, leading to viscosity reduction. Tao & Huang (2011) observed that after the blood sample was exposed to a magnetic field of 1.33T parallel to the flow direction for 1 min, the viscosity dropped from 5.7 cS to 4.37 cS (23.3%). They believe that this viscosity reduction can be beneficial for blood flow in all kinds of blood vessels.

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 4). The results of the tests are not always straightforward, which often makes them challenging to interpret and explain. 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. Note that the bicarbonate reduction is associated with ammonium excretion due the metabolism from glutamine. The rate of renal bicarbonate and ammonium production is regulated in response to changes in systemic acid-base status and decreases during metabolic alkalosis. It is important to consider that 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 bone densitometry thereby reducing competition for calcium binding sites. There was a higher iCa in rats drinking water treated by magnetic field (Table 4).

Table 4 Magnetic treatment of water on viscosity, biochemical profile and blood gas level

	Control	Test	CV	MSE	Pr>F
Viscosity 60 (cP)	2.63	2.18	35.58	0.848	0.405
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**	**1.339**	**3.433**	**0.045**	**0.066**
Ph	7.32	7.31	0.545	0.039	0.697
pO_2 (mmHg)	**69.38**	**86.02**	**16.77**	**13.14**	**0.043**
pCO_2 (mmHg)	**53.85**	**46.40**	**15.284**	**7.624**	**0.081**
PHt	7.29	7.28	0.546	0.039	0.572
pO_{2t} (mmHg)	**77.33**	**96.87**	**16.42**	**14.43**	**0.033**
pCO_{2t} (mmHg)	60.11	51.73	15.32	8.52	0.080
SO_2 (%)	**91.75**	**94.60**	**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**	**25.04**	**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**	**16.95**	**10.65**	**1.705**	**0.047**

Within rows, means with different letters are significantly different ($P<0.05$).

There was significance interaction between the two types of water (control and test) and the three consumption period (15, 30 and 45 days of consumption) on BR, BMD and BMC ($p<0.05$). In the first analysis (after fifty days), there was no difference ($p<0.05$) in BMC or BR between the two groups. In the second evaluation (after thirty days), there were increases in BR (mid shaft), BMD and BMC ($p<0.05$). After forty-five days, there were increases in BR, BMD and BMC ($p<0.05$) and the differences between the groups were bigger (Table 5). Thus, the effects were attributed to reduced hydrogen ions competing for calcium binding sites. Whereas calcium is a major structural element in bones and is a key player to bone health, calcium absorption and higher iCa favors a better densitometry.

There are too many positive and negative ions in the body fluids. Most ion channels simply allow ions to flow in or out of the cell. The normal tendency is for everything inside and outside a cell to balance out this way. The flow of body fluids means ions flow and results in an electric chain. If there is a magnetic flow, the flow of ions changes and becomes organized and faster, stimulating the ions channels that carry body fluids [7]. From a biological point of view, according to Coey & Cass (2000), the influence of the magnetic treatment persists for more than two hundred hours and this way, this magnetic memory allows effects into the body after water intake. These changes have a favorable impact on life and makes efficient which behaves biologically, favoring in humans increased irrigation and the flow of blood [15].

Table 5 Magnetic treatment of water on Bone Mineral Density (BMD, g/cm^2), Bone Mineral Content (BMC, g) and Bone Resistance (BR, kN/m) of rats.

Days of consumption	Control	Test	CV	MSE	*P*-value
	Bone Mineral Content				
15	0.123	0.134	26.48	0.034	0.511
30	0.169 [b]	0.215 [a]	10.19	0.019	0.0003
45	0.201 [b]	0.296 [a]	12.01	0.030	<0.0001
	Bone Mineral Density				
15	0.096 [b]	0.114 [a]	17.82	0.018	0.075
30	0.137 [b]	0.173 [a]	6.92	0.010	<0.0001
45	0.141 [b]	0.200 [a]	6.09	0.010	<0.0001
	Mid shaft Femoral Resistance				
15	317.94	349.89	19.51	65.17	0.377
30	438.33 [b]	531.22 [a]	15.66	75.47	0.033
45	436.06 [b]	567.61 [a]	14.37	72.15	0.005

Within rows, means with different letters are significantly different (P<0.05).

Conclusion:

We concluded that there were increases in BMD, BMC and BR in group consuming water conditioned by magnetic field technology compared to group consuming unconditioned water. Furthermore, the highest consumption period of the water conditioned by magnetic field increased BMD, BMC and BR in rats. The treated water intake for more than 45 days provides an effective way to improved bone mineral content and can reduce the risk of osteoporosis and bone fractures by reducing Hydrogen competition for Calcium binding sites.

Competing interests: The authors have no financial interests or conflicts of interest.

Authors' contributions: All authors contributed to this study.

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REFERENCES:

1. Consensus Development Conference. Diagnosis, prophylaxis and treatment of osteoporosis. Am J Med 1993; 94: 646–650.

2. Marshall D, Johnell O, Wedel H. Meta-analysis of how well measures of bone mineral density predict occurrence of osteoporotic fractures. BMJ 1996; 312: 1254–1259.

3. Goulding A, Jones IE, Taylor RW, Manning PJ, Williams SM. More broken bones: a 4-year double cohort study of young girls with and without distal forearm fractures. J Bone Miner Res 2000; 15: 2011–2018.

4. Al-Mufarrej, S.; Al-Batshan, H.A.; Shalaby, M.I.; Shafey, T.M. The Effects of Magnetically Treated Water on the Performance and Immune System of Broiler Chickens. International Journal of Poultry Science, 2005; 4(2): 96-102.

5. Balieiro, G.N.; Nogueira, J.R.; Pinheiro, M.G.; Rodini Filho, J.E.; Molinaro, C.M.C.; Luz e Silva, S. Effects of magnetic treated water on serum concentration parameters and fat thickness. Bulletin of Animal Husbandry, 2013; 70(2): 158-166.

6. Cho, Y.I. & Lee, S.H. Reduction in the surface tension of water due to physical water treatment for fouling control in heat exchangers, Int. Commun. Heat Mass Transfer 1 2005; 1–9.

7. Coey, J.M.D. & Cass, S. Magnetic water treatment. Journal of Magnetism and Magnetic Materials 2000; 209: 71-74.

8. Fisher, E.W.; Sibartie, D.; Grimshaw, W.T.R. A comparison of the pH, pCO2, pO2 and total CO2 content in blood from the brachial and caudal auricular arteries in normal cattle. British Veterinary Journal 1980: 136; 496-499.

9. Levy, D.; Holzer, Z.; Brosh, A.; Ilan, D. The effect of magnetically treated drinking water on performance of fattening cattle. Agricultural Research Organisation, Haifa, Israel. Harari, M. and I. Lin, 1990.

10. Lin I.; Yotvat, J. Exposure of irrigation water to magnetic field with controlled power and direction: effects on grapefruit. Alon Hanotea 1989: 43; 669-674.

11. Patterson, D.C; Chestnutt, D.M.B. The effect of magnetic treatment of drinking water on growth, feed utilization and carcass composition of lambs. Animal Feed Science Technology 1994: 46; 11-21.

12. Sargolzehi, M.M.; Rezaee, R.A.; Naserian, A.A. The effects of magnetic water on milk and blood componentes of lactating Saanen goats. International Journal of Nutrition and Metbaolism 2009: 1(2); 20-24.

13. SAS Institute Inc. SAS User`s guide: statistics. Ver. 5 ed., SAS Inst., Cary. NC, 1985.

14. Standard Methods for the Examination of Water and Wastewater; APHA, AWWA, and WEF, 21st, Edition, 2005.

15. Tao, R. & Huank, K. Reducing Blood Viscosity with Magnetic Fields. Physical Review E 2011: 84; 1-5.

16. Good, D.W. New Concepts in Renal Ammonium Excretion. In: D.W. SELDIN & G. GIEBISCH (Ed.). The Regulation of Acid-Base Balance. New York, 1989, p.603.