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The Effects of Magnetically Treated Water on the Performance and Immune System of Broiler Chickens

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Abstract: The effects of water treatment (tab water (CTW) vs. magnetically treated water (MTW)) on the performance (body weight gain, feed intake, feed conversion ratio (feed/gain)) from day to 32 days of age, water consumption (WC) and Water: feed consumption ratio (WFR) during the first three weeks of age (starter phase), carcass composition at 32 days of age, and antibody responses to SRBS antigens of sexed broiler chickens were investigated. MTW was prepared by exposing the water to a magnetic field of approximately 500 gauss. The exposure of water to the magnetic field slightly increased the pH of water from 7.72 to 7.86. The water treatment influenced WC of birds. The daily WC of birds on the MTW was significantly ($P<0.05$) lower than those on the CTW during the starter phase. The MTW did not influence the WFR during the starter phase, and performance and carcass composition of birds at 32 days of age. Sex of birds influenced body weight gain, and carcass composition at 32 days of age and WC over the starter phase. Males consumed more water, and had a heavier weight gain with high proportions of thigh and drumstick in their carcasses than females. Sex of birds did not influence feed intake and FCR at 32 days of age, and WFR at the starter phase. Water treatment and sex of bird did not influence antibody responses to SRBC antigens. There were significant interaction between water treatment and sex of birds on feed intake, weight gain, WC, and thigh proportion of the carcass. Males consumed more feed and water and had a higher weight gain than females when they drank the CTW, but not when they drank the MTW. Males had a higher thigh proportion in their carcasses than females when they drank the MTW, but not when they drank the CTW. It is concluded that the exposure of tab water to a magnetic field of approximately 500 gauss reduced water consumption, but did not significantly influence the performance, carcass composition and immune system of broiler chickens. Additionally, magnetically treated water reduced the difference in the performance between sexes of broiler chickens to a non-significant level.

Key words: Magnetically treated water, broiler chickens, performance, immune system

Introduction

Water is the blood of life. It is needed to transport compounds via the blood, maintain cellular structural integrity, regulate temperature, etc. (Reuter, 2004). Water is a very simple molecule, consisting of two hydrogen atoms attached to an oxygen atom. Although the water molecule as a whole has no charge, the parts of it, the hydrogen wings and the oxygen body, do exhibit individual opposite charges. Since opposite electrical charges attract, water molecules tend to attract each other (Kegley and Andrews, 1998). Water in living systems naturally gathers into structures of 14, 17, 21, 196, 280, or more molecules (Mikesell, 1985; Daviss, 2004). Structured water can be formed using magnets (Mikesell, 1985). There is a long history of the promotion of magnets to improve the quality and health benefits of water. Researchers found when a permanent magnet is kept in contact with water for a considerable period of time; the water gets magnetically charged and acquires magnetic properties. Such magnetically treated water has its effect even on the human body when taken internally and regularly for a considerable period of time (Lam, 2001). Physics shows that water change weight under the influence of magnetic fields. More hydroxyl (OH-) ions are created to form alkaline molecules, and reduce acidity. Normal water has a pH level of about 7, whereas magnetized water can reach pH of 9.2 following the exposure to a 7000 gauss strength magnet for a long period of time (Lam, 2001).

Moreover, the property of magnetism is present in every living cell (Slawinski, 1988; Popp, 1989; GU, 1992). According to many researchers that the equilibrium of living cell can be restored-with the help of magnets (Lam, 2001). A wide variety of magnetic water devices is available (Magnetic Technologies LLC, 2000-2003). These devices consist of one or more permanent magnets affixed either inside or to the exterior surface of the incoming water pipe. The water is exposed to the magnetic field as it flows through the pipe between the magnets to structure water. However, less seems to be known about the effects of magnetic field on the physical and chemical properties of water. Water and water solutions passed through the magnetic field acquire finer and more homogeneous structures (Tkachenko and Semyonova, 1995). This increases the fluidity, dissolving capability for various constituents like minerals and vitamins (Kronenberg, 1985; Mikesell, 1985), and consequently improves the biological activity of solutions affecting positively the performance of human, animal and plants (Lin and Yotvat, 1989 and 1990; Tkachenko and Semyonova, 1995; Goldsworthy *et al.*, 1999).

A literature search for the effect of magnetically treated water (MTW) on the performance of poultry revealed that such studies are practically nonexistent, so clearly that such studies has received no attention from the scientific community. However, there are two sketchy references describing the positive effects for using MTW on the performance of animals. However, these references did not provide any supporting data (Kronenberg, 1993; Lin, 1995). The important question here, though, is whether MTW works. This experiment was designed to examine the effects of MTW on the performance, water consumption, immune system and carcass composition of broiler chickens.

Materials and Methods

Birds and Housing: A total of 144 of comparable weight, day-old sexed broiler chicks (Ross, Al-Wady Poultry Farms, Saudi Arabia) were randomly assigned into twelve replicates of six birds each per sex. Birds were housed in electrically heated battery cages. The experiment was a 2 x 2 factorial, the variable being water treatment (tap water (CTW) and magnetically treated tab water (MTW) and sex of birds. Six replicates per sex were randomly assigned to one of the two water treatments. Lighting was incandescent and continuous throughout the experiment period. All birds were fed a commercial starter diet (22% protein and 3100 ME kcal/kg) to 21 days (starter phase), followed by a finisher diet (20% protein and 3200 ME kcal/kg) until the termination of the experiment at 32 days of age (22-32 days, finisher phase). Feed and water were provided *ad libitum*. The weights of chickens and feed consumption were recorded weekly. Water consumption was recorded over two consecutive days each week during the first three weeks of the experiment. At the end of the experiment, six birds per treatment per sex were randomly selected and processed at King Saud University to determine processing yields and carcass quality.

The preparation of MTW: Water was passed through a magnetic funnel (Magnetic Technologies LLC, Registered Pattern No. 1826921) at relatively low speed to prevent overflow and collected into graduated cylinders for distribution. Chickens were provided with fresh MTW every 12 hours following the recommendations of the magnetic funnel manufacturer (Magnetic Technologies LLC). According to the manufacturer that water retains the magnetic properties for up to 12 hours following the passing of water through the magnetic field of the funnel. The pH of the MTW was measured using a pH meter (Extech-Ex900). The funnel's magnetic field consists of seven pairs of successive magnets. Each magnet had a circle shape with a diameter and thickness of 7.72 and 4.96 mm, respectively. The strength of the magnets was between 450 to 500 Gauss as measured by a gauss meter (AlphaLab, Inc.)

Antibody response to sheep red blood cells (SRBC) antigen: Six males and six females from each treatment were injected with 0.2 mL of 7% SRBC antigen suspended in 0.9% saline at 16 days of age to the back of the neck. Blood samples were collected via the wing vain before injection and at days 5, 10, and 15 of post immunization. Sera were separated by centrifugation at 3000 rpm and stored at -20°C until all samples were analyzed simultaneously. The antibody production to SRBC was measured by the micro titer hemagglutination assay as described by Munns and Lamont (1991). Chickens receiving the SRBC were maintained in separate cages for the duration of the experiment. Antibody titers data were transformed to reciprocal $\log_2$ units.

Data collected were subjected to analysis of variance using GLM procedures (SAS, 1985). Where significant variance ratios were detected, differences between treatment means were tested using the least significant difference (LSD) procedures. A difference with a probability of $P<0.05$ was considered significant. Measurements were made of body weight gain, feed consumption, feed conversion ratio (FCR, feed intake/weight gain), water consumption (WC), water: feed consumption ratio (WFR), and serum antibody titers of SRBC and carcass composition.

Results

The effects of MTW and sex of broiler chickens on the performance, water consumption, carcass composition and response to SRBC antigens are shown in Table 1 to 3 and Fig. 1, respectively. Birds on the MTW had a significantly ($P<0.05$) lower daily WC during the starter phase when compared with those on the CTW treatment. Birds on the CTW treatment consumed significantly more feed ($P<0.05$) during the finisher phase, and had higher ($P<0.01$) WC rate and WFR during the second week of age when compared with birds on the MTW. However, the MTW did not significantly influence the body weight gain, feed intake, and FCR of birds (Table 1), and carcass composition at 32 days of age (Table 3), WFR at the starter phase (Table 2), and anti-SRBC titers of chickens (Fig. 1).

Sex of birds influenced weight gain, WC, and carcass composition. The weight gain of males was significantly heavier than those of females during the finisher phase

Table 1: Body weight gain, feed intake and feed conversion ratio of sexed broiler chickens drank either tab water (CTW) or magnetically treated water (MTW) between day and 32 days of age

Treatment		Starter phase (day -21 days of age)		
		Weight gain (g)	Feed intake (g)	FCR[1] (feed/gain)
Water (W)	CTW	559.3+14.1	919.2+23.0	1.64+0.05
	MTW	556.9+11.5	913.5+15.6	1.65+0.03
Sex of bird (S)	Male	567.3+10.2	929.0+20.1	1.64+0.03
	Female	546.9+14.6	900.6+17.2	1.65+0.05
LSD[2] (P<0.05)		26.7	39.7	0.12
Interaction W X S		**	*	NS
		Finisher phase (22-32 days of age)		
Water (W)	CTW	811.3+15.2	1430.2+21.8	1.77+0.01
	MTW	768.9+19.7	1375.1+16.1	1.80+0.05
Sex of bird (S)	Male	813.2 + 10.4	1417.6 + 20.7	1.74+0.02
	Female	758.1+23.9*	1380.9+16.4	1.83+0.05
LSD[2] (P<0.05)		48.4	57.7	0.11
Interaction W X S		NS	**	NS
		Starter plus finisher phases (day-32 days of age)		
Water (W)	CTW	1370.7+27.6	2353.4+28.9	1.72+0.02
	MTW	1325.8+19.5	2286.6+22.5	1.73+0.02
Sex of bird (S)	Male	1380.5 + 20.6	2346.6 + 24.5	1.70 + 0.02
	Female	1305.0+22.5**	2281.5+25.6	1.75+0.02
LSD[2] (P<0.05)		52.4	80.4	0.07
Interaction W X S		*	**	NS

[1]FCR = Feed conversion ratio (feed intake/weight gain). [2]Least significant difference (P<0.05). [NS]Not significantly different (P>0.05).
*Significantly different at (P<0.05). **Significantly different at (P<0.01).

Table 2: Water consumption (WC) and water: feed ratio (WFR) of sexed broiler chickens drank either tab water (CTW) or magnetically treated water (MTW) between day and 32 days of age

Treatment		Age (week)			
		1		2	
		WC (ml/bird/day)	WFR (ml/gm)	WC (ml/bird/day)	WFR (ml/gm)
Water (W)	CTW	42.4± 2.0	2.38± 0.12	72.0± 2.5	1.76± 0.07
	MTW	452±1.7	2.66±0.09	62.4±1.1	1.45±0.04
Sex of bird (S)	Male	44.5±1.6	2.63± 0.11	68.8±2.4	1.62±0.06
	Female	43.3±2.1	2.41± 0.11	64.3±2.0*	1.55± 0.09
LSD[1] (P<0.05)		5.3	0.31	5.1	0.18
Interaction W X S		NS	NS	NS	NS
Treatment		Age (week)			
		3		Starter phase (day - 21 days of age)	
		WC (ml/bird/day)	WFR (ml/gm)	WC (ml/bird/day)	WFR (ml/gm)
Water (W)	CTW	94.0+2.2	1.32+0.04	69.5+1.9	1.60+0.05
	MTW	89.7+1.3	1.28+0.02	65.7+0.8*	1.51+0.03
Sex of bird (S)	Male	93.8±1.9	1.29±0.04	69.0±1.5	1.57±0.04
	Female	88.9±1.3	1.30±0.02	65.5±1.2	1.53±0.03
LSD[1] (P<0.05)		4.2	0.1	3.5	0.11
Interaction W X S		*	NS	*	NS

[1]Least significant difference (P<0.05). [NS]Not significantly different (P>0.05). *Significantly different at (P<0.05).
**Significantly different at (P<0.01).

Table 3: Body composition of sexed broiler chickens at 32 days of age drank either tab water (CTW) or magnetically treated water (MTW) between day and 32 days of age

Body composition	Water treatment (W)		Sex of bird (S)		LSD $(P<0.05)^1$	Interaction W X S
	CTW	MTW	Male	Female		
Live body weight (g)	1614.5+27.4	1555.7+41.5	1596.5+37.4	1573.7+34.8	106.5	NS
Carcass weight (g)	1152.1+22.5	1098.0+29.9	1121.2+33.5	1128.8+20.2	77.0	NS
g/kg live body weight						
Carcass weight (g)	713.4+4.9	706.5+10.6	701.6+9.2	718.4+6.4	22.7	NS
g/kg carcass weight						
Thigh	169.2+4.4	165.7+6.6	178.2+4.6	156.8+4.6**	12.3	*
Drumstick	124.4+2.4	127.2+3.8	131.2+3.0	120.4+2.6*	8.5	NS
Breast	282.1+6.7	272.9+8.1	278.6+6.4	276.4+8.6	23.0	NS
Back	222.5+6.2	230.5+9.3	219.8+6.7	233.2+8.6	23.8	NS
Neck	65.4+2.9	65.4+4.3	66.9+3.5	63.8+3.7	11.1	NS
Abdominal fat	20.1+1.9	16.8+1.6	17.3+1.6	19.6+2.0	5.2	NS

[1]Least significant difference (P<0.05). [NS]Not significantly different (P>0.05). *Significantly different at (P<0.05).
**Significantly different at (P<0.01).

(P<0.05) and starter plus finisher phases (P<0.01). Males had significantly (P<0.05) higher rate of WC than females during the second and third weeks, and over the whole starter phase period. The proportions of thigh and drumstick in the carcass of male were significantly (P<0.01 and P<0.05, respectively) higher than their counterparts of female carcass. There was no significant difference between sexes of birds in FCR (Table 1), WFR (Table 2), and antibody responses to SRBC antigens (Fig. 1).

There was significant interaction between water treatment and sex of birds on the feed intake during all stages of experimental period [starter phase (P<0.05), finisher phase (P<0.01) and starter plus finisher phases (day to 32 days of age, P<0.05)], weight gain of birds during the starter (P<0.05) and starter plus finisher phases (P<0.05), rate of WC during the third week and starter phase period (P<0.05) and thigh proportion in the carcass (P<0.05) at 32 days of age. Male birds on CTW had higher consumption rates of feed during all stages of experimental period (Fig. 2), and water during the third week and the starter phase (Fig. 3) and body weight gain during the starter phase, and starter plus finisher phases (Fig. 4) than female birds on the same water treatment. On the other hand, sex of birds did not influence the consumption of feed and water, and weight gain of birds at any stage of experimental period when they drank from the MTW. Males had a higher thigh proportion in their carcasses than females when they drank the MTW, but not when they drank the CTW. There was no significant interaction between water treatment and sex of birds on antibody responses to SRBC (Fig. 5).

Discussion

Results from this study showed that MTW reduced daily water consumption of birds by approximately 5.46%, without any significant effect on the performance, WFR, carcass quality and immune system of meat chickens. Additionally, the water type strongly affected the performance of both sexes of birds, differently (Fig. 2 to 4). Males on the CTW consumed more feed and water, and grew heavier when they were compared with females from the same treatment group. Whilst there was no significant difference in water and feed consumption, and body weight gain between males and females drank the MTW. Comparing the two treatments within either sex revealed that the MTW, significantly, reduced water and feed intakes, and body weight gain of males by approximately 11.0, 7.86 and 6.78%, respectively, and non-significantly increased water and feed intakes, and body weight gain of females by approximately 2.11, 4.76 and 2.81%, respectively, when they were compared with their counterparts on the CWT. These findings may suggest that male broiler chickens are more sensitive than female broiler chickens to MTW. The reason (s) for the altered performance of sexed broiler chickens on the MTW as compared with CTW is not clear. There is no information available on factors that cause variation in the response to MTW. Further studies may be needed to clarify this point. These findings were not in agreement with Kronenberg (1993) and Lin (1995) who reported that MTW improved the performance of farm animals (chickens, turkeys, pigs, cows, calves, and sheep). These researchers did not provide any data to support their findings or mention the conditions of their experiments. It is unclear whether the positive reports are due solely to magnetic treatment or to other conditions that were not controlled during the trials. Additionally, there has never been a reviewed paper in scientific journal validating any of the performance adding effect of MTW that claimed by the supplier of magnetic devices. Our results, also indicated that MTW did not influence the immune system

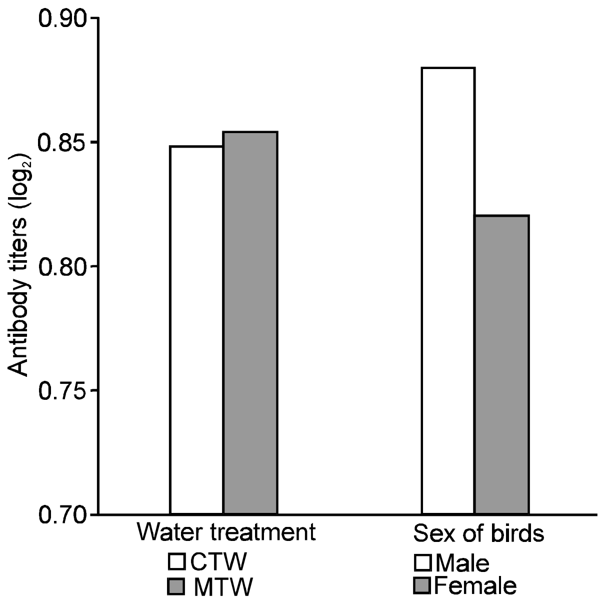

Fig. 1: Antibody SRBC-titers ($\log_2$) in male and female broiler chickens drank tab water (CTW) and magnetically treated water (MTW)

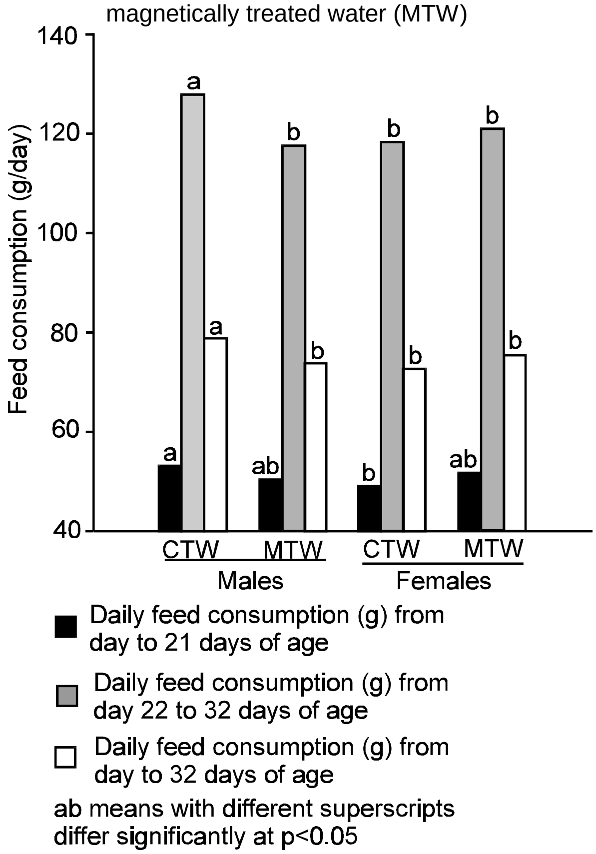

Fig. 2: Daily feed consumption (g) of sexed broiler chickens drank tab water (CTW) and magnetically treated water (MTW) from day to 32 days of age

of chickens (Fig. 1). This finding was in agreement with Battocletti *et al.* (1981); Bellossi and Toujas (1982); Tenforde and Shifrine (1984); Osbakken *et al.* (1986) who reported no effect for static magnetic field of 130-20,000 gauss on the immune system of animals. In contrast, magnetic treatment has been claimed to help the body ward off microbial invaders and improve immune system (Lam, 2001, magnetic technologies LLS, 2000-2003).

There is apparently disagreement among magnet suppliers regarding the mechanisms by which magnetic water treatment occurs. A variety of explanations are offered, most of which involve little scientific substance. Some researchers hypothesize that magnetic treatment affects the nature of hydrogen bonds between water molecules. They report changes in water properties such as light absorbency, surface tension, and pH (Joshi and Kamat, 1966; Bruns *et al*., 1966; Klassen, 1981). However, these effects have not always been found by other investigators (Mirumyants *et al*., 1972). Further more, the characteristic relaxation time of hydrogen bonds between water molecules is estimated to be much too fast and the strength of the applied magnetic field is much too small for any such lasting effects, so it is unlikely that MTW affects water molecules (Lipus *et al*., 1994). Barrett (1998) with the help of Dr. Farley, a Professor of Physics at the University of Nevada, Las Vegas answered some of the claims related to the MTW. He wrote that if an external magnetic field applied to a water sample, the water would develop a temporary internal magnetic field about 100,000 times weaker than the external field. This tiny effect goes away as soon as the external magnetic field is removed. Therefore, assuming that the magnetic field exerts a minuscule effect on the passing water, this effect would disappear as soon as the water leaves the magnetic field. However, magnetic device manufacturer (Magnetic Technologies LLC) claimed that the water retains the magnetic properties for up to 12 hours following the magnetizing treatment.

The main question is that would MTW survive the journey through the stomach and gut contents and into the intestines where they would be absorbed. Our study has shown that magnetic treatment of water caused a very slight increase in the pH of drinking water with total dissolved solids of 530 (7.72 to 7.86) and distilled water (4.70 to 4.72). However, pH of water was significantly increased from 7 to 9.2 when exposed to a strong magnetic field of 7000 gauss (Lam, 2001). The differences in the pH of MTW between the two studies may be due to differences in the strength of the magnetic fields used in these studies. The magnetic field used in our study was approximately 500 gauss. However, the non-significant change in the pH of water in our study will not influence the production of hydrochloric acid and

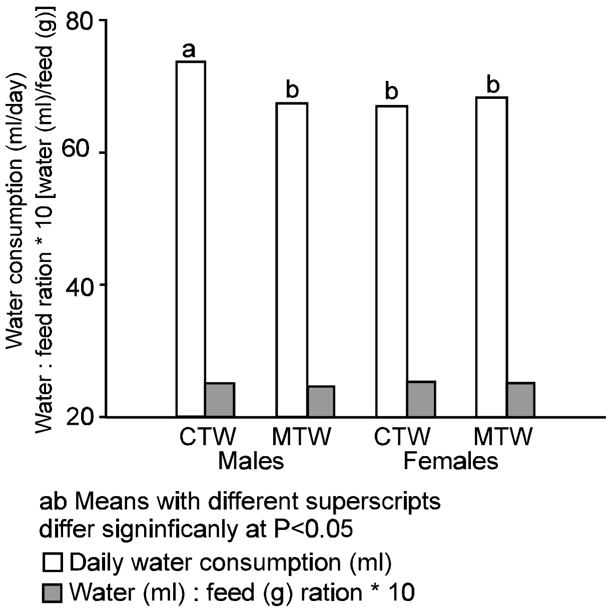

Fig. 3: Daily water consumption (mL) and water : feed ratio [water (ml)/feed (g)] of sexed broiler chickens drank tab water (CTW) and magnetically treated water (MTW) from day to 21 days of age.

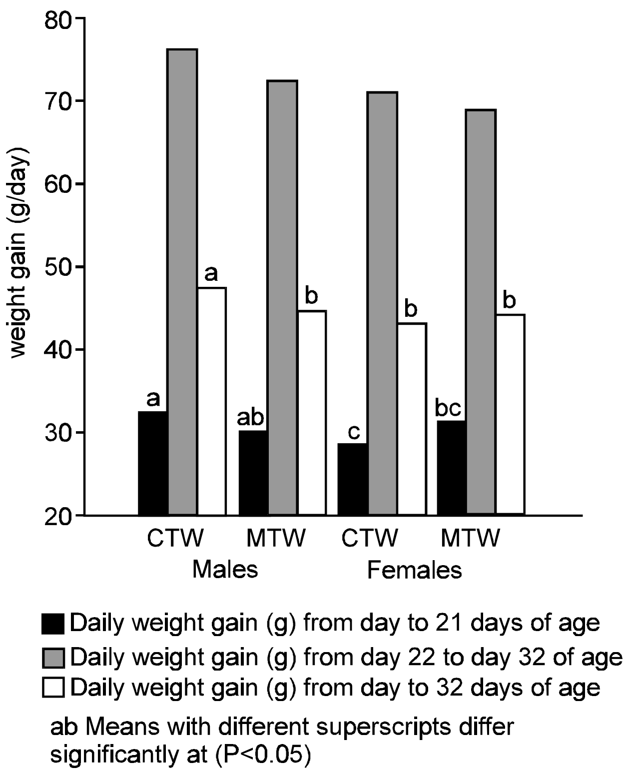

Fig. 4: Daily weight gain (g) of sexed broiler chickens drank tab water (CTW) and magnetically treated water (MTW) from day to 32 days of age

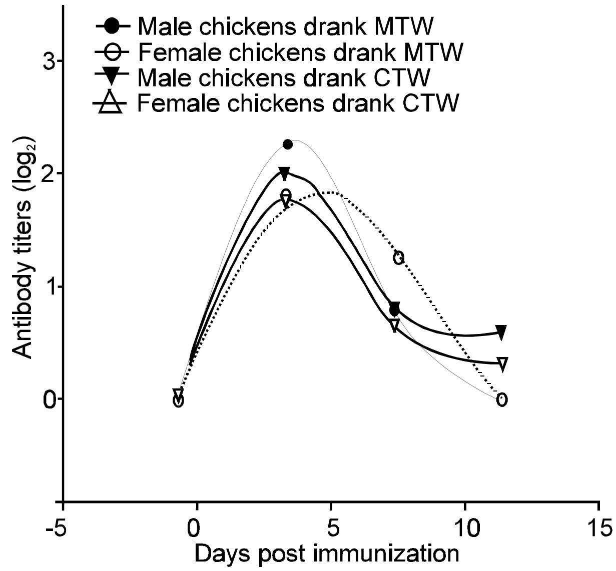

Fig. 5: Antibody SRBC-titers (log2) at 5, 10 and 15 days of post-immunization in male and female broiler chickens drank tab water (CTW) and magnetically treated water (MTW)

consequently will not cause any change in the pH of the gastrointestinal tract of birds. Additionally, pH of water does not influence its rate of absorption into the body. Mainly secretions of the cells lining the stomach and small intestine determine the pH of the fluid within the stomach and intestines. Even if exposure to a magnet could change the rate of water absorption into the body, the speed of absorption of a small amount of water would have no effect on how the body functions. There is no scientific agreement about how MTW might function in the body. As far as body is concerned, water is water, it will be utilized equally well by the bird regardless of any treatment methods use on.

Whether or not some magnetic water treatment effect actually exists, the most important for poultry producers, is whether the magnetic water treatment devices improve the performance of chickens as advertised. At present, it seems quite unlikely that any of the claimed benefits of MTW on the performance of chickens are real. Until such data become available, considerable scepticism is justified. There is no guideline offered by the supplier of magnetic devices for determining when the desired effect can be expected and when it cannot. Moreover, there are other important factors that influence the outcome of MTW and should be investigated before any final conclusion regarding such treatment. These include factors influence the strength of the magnetic field (such as the number of magnets, shape of the magnet, space between magnets), the space between the water and the magnetic field, and quantity of water and period of contact with the magnetic field, and finally way (s) to evaluate the MTW.

In conclusion that MTW did not influence the performance, water consumption, carcass quality and immune system of chickens. We found no reviewed paper in any scientific journal validating any performance adding effects of MTW that support the claims made by the supplier of magnetic devices. It appears that the knowledge of magnetic water treatment must first be developed to the point where the effects of magnetic treatment can be reliably predicted and shown to be economically attractive.

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