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Rabbit-does Performance as Affected by Different Types of Water Exposed to Magnetic Field

Helal, A.[1], Aya G.Abd-Elazeem[1], Ibrahim N.H.[1] and Mohamed M.Y [2]

[1]Animal and Poultry Production Department, Faculty of Agriculture, Beni-Suef University.
[2]Animal Production Research Institute (APRI), Agricultural Research center (ARC)

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Corresponding author:
Mahmoud Yassin Mohamed
Email:
dr.yassin2005@gmail.com

ABSTRACT

The present study was to determine how different types of water, like well water (WW) and tap water (TW), affected the performance of rabbit-does when they were exposed to a magnetic treatment of about 10000 gausses. Forty-eight weaned female V-line rabbits were divided into six groups (8 each). 1st and 2nd groups involved TW whether exposed to magnets or not (TW vs. MTW). The other groups involved the well water using the same method while the 3rd and 4th groups with TDS 4000 ppm (WWA vs. MWWA) and the 5th and 6th groups with TDS 6000 ppm (WWB vs. MWWB). The results indicated that magnetization had a higher impact on WW, whether 4000 or 6000 ppm than on TW. Feed intake significantly ($P < 0.001$) decreased, while average daily gain, growth rate, and feed conversion ratio significantly ($P < 0.001$) improved. WW reduced ($P < 0.001$) litter size, litter weight at birth & weaning and milk yield compared to TW. WW reduced ($P < 0.001$) serum protein profile, liver enzymes, ovarian hormones, and aldosterone hormone but raised serum sodium and chloride. When water was exposed to a magnetic treatment boosted ($P < 0.01$) litter size, litter weight at birth & weaning and milk yield and enhanced milk conversion ratio and improved levels of liver enzymes, and ovarian hormones compared to unmagnetized water. The use of magnetization, particularly in salt water, reduces the adverse effects of salinity and enhances the quality of the water.

KEYWORDS: Rabbit does, water, magnetic, growth, reproductive

1. INTRODUCTION

Water is necessary for all biologically responses, chemical transportation, cellular integrity, controlling body temperature, and other processes. On a weight basis, birds often drink twice as much water as they do feed, and poor quality water has been demonstrated to affect animal performance and elevate health risks (Attia *et al.*, 2013). To improve water quality, magnetic technologies could be used instead of chemical softening (Eisenberg *et al.*, 1993; Verma, 2011). Water that had been in close proximity to a permanent magnet for an extended period of time generated magnetic charges and characteristics. Magnetized water can strengthen the immune system, reduce lime accumulation microbiological count in pipes, so improves water permeability through biological barriers, and impacted the concentration of water minerals (Kronenberg, 1985; Lam, 2001). Exposure of salinity water to a magnetic field may provide a solution for enhancing reproductive performance, liver, kidney, ovarian function, and the levels of antioxidant in rabbit-does and their offspring and nutrient component in milk like total solid, fat, protein, lactose, and non-fat solid (El-Hanoun *et al*., 2013). Helal *et al*. (2022) reported that magnetization, particularly when used with well water, reduces the negative impact of salinity on growth rate and feed conversion ratio for growing rabbits. Also, they revealed that magnetic water had a beneficial effect on rabbit's performance, carcass characteristics, serum glucose, urea, and lipid profile. On the contrary, Sargolzehi *et al*. (2009) had the opposite results in lambs and goats. Al-Mufarrej *et al*. (2005) observed that using magnetized water significantly reduces the differences between male and female broilers. Gholizadeh *et al*. (2008) reported that chickens who drank magnetic water grew faster than those who drank nonmagnetic water, had a greater meat-fat ratio, livability, and production efficiency, and had a lower mortality rate.

The purpose of this study was to assess the improved effect of magnetization on salty water and tap water in order to decrease the negative effects of saline water and enhance its quality, as well as to increase the quality of tap water and thus improve the productive and reproductive performance of rabbit-does when drinking this water.

2. MATERIALS AND METHODS

This study was conducted in cooperation between the Faculty of Agriculture, Beni-Suef University, and Animal Production Research Institute (APRI), Agriculture Research Center (ARC), Ministry of Agriculture, Egypt, during the period from November 2021 to May 2022. The study proposal was to determine how magnetization affected both salinity water and tap water, in an effort to lessen the negative effects of salinity water and enhance its quality as well as to enhance the quality of tap water. Forty-eight weaned female V-line rabbits were used as experimental animals in this investigation, aged 60-days with average body weight (BW) 1.05±0.02 kg, and continuing to reach maturity. The rabbits were placed under observation for 10-days before beginning the experiment to rule out any latent infections. Rabbits were randomly distributed individually into equal 6 groups, (8 each): 1st group (TW) drank unmagnetized tap water and served as control, 2nd group (MTW) drank magnetized tap water, 3rd group (WWA) drank unmagnetized well water A (4000 ppm), 4th group (MWWA) drank magnetized well water A (4000 ppm), 5th group (WWB) drank unmagnetized well water B (6000 ppm), and 6th group (MWWB) drank magnetized well water B (6000 ppm). The strength of the magnetic flux density was 10000 Gauss. Galvanized metal rabbit battery cages measuring 60 by 50 by 40 cm and outfitted with individual feeders were used to house the experimental rabbits. All treated does were natural mating post-maturity with adult V-line bucks with good fertility records and not significant differences among them. On day 10 following service, an abdominal palpation revealed pregnancy. Water was accessible from automatic nipple drinkers, and pelleted meals were also offered *ad libitum* throughout the trial period. Both feed intake (FI) and BW were recorded biweekly. Body weight gain (BWG), growth rate (GR) and feed conversion ratio (FCR) were computed. Milk yield was recorded twice weekly as the increase in kid's weight, resulted from weighing the kids before and after suckling, following 12 hours' deprivation of kids from suckling their mothers.

The diet consisted primarily of commercial pelleted of clover hay, wheat bran, Yellow corn, soybean meal, DL-methionine, molasses, vitamin plus mineral premix and sodium chloride. Approximate chemical analysis of the diet was done according to AOAC (2007), whereas neutral detergent fiber (NDF) and acid detergent fiber (ADF) were according to the following equations: % NDF= 28.924 + 0.657 (%CF); % ADF = 9.432 + 0.912 (%CF); Hemicellulose= %NDF - % ADF. The chemical composition showed that crude protein (17.02%), crude fiber (13.25%), ether extract (2.72%), nitrogen free extract (52.14%), ash (6.56%), methionine (0.61), lysine (0.75%), NDF (37.36%), ADF (21.52%) and hemicellulos (16.11%).

Table 1. Analysis of well and tap water samples used in the current study.

Parameters	Tap water		Well water A		Well water B	
	(–)	(+)	(–)	(+)	(–)	(+)
TDS (mg/l)	272	278	3974	4001	5984	5997
Total Hardness	204	220	998	1026	1512	1574
pH (mg/l)	7.47	8.08	7.62	7.9	7.54	7.88
Conductivity (µS/cm)	576	583	9710	9770	14050	14080
K (mg/l)	4.55	5.12	67.07	69.07	111.16	121.86
Na (mg/l)	59.86	64.36	938.85	942.27	1461.65	1463.08
Mg (mg/l)	23.73	29.72	125.3	126.7	224.6	241.5
Ca (mg/l)	42.24	46.88	326.4	367.2	544.8	640.5
Chloride (mg/l)	67.5	70.3	2723.5	3091.8	4376.2	4533.9
Alkalinity (HCO_3 , mg/l)	180.6	186.2	158.3	158.7	173.06	173.08
CO_3 (mg/l)	0	0	0	0	0	0

(-) without magnetic exposure; (+) with magnetic exposure; A, 4000ppm; B, 6000ppm.

The calculated digestible energy value was 2500 kcal/kg diet. Water was analyzed physically and chemically to determine TDS, total hardness, pH, conductivity, potassium, sodium, magnesium, calcium, chloride, alkalinity and carbonate as presented in Table 1.

Blood samples were collected monthly from the marginal ear to reached maturity for biochemical assay, and at day 15 after mating from five fertilized does in each treatment for estradiol (E_2) and progesterone (P_4) hormones assay. Blood samples were placed in a sterile vacutainer tubes and allowed to coagulate for serum preparation by centrifugation at 1.370 × g for 15 min. at 4 ºC and then transferred into sterilized tubes and stored at - 20 °C till used.

Serum total protein (TP), albumin (ALB), alanine aminotransferase (ALT), and aspartate aminotransferase (AST) concentrations were assayed according to Young (2000) method using bio-systems automated reagent kits obtained from Costa Brava 30, Chemical Company, Barcelona (Spain). Globulin (GLO) content as calculated by calculating the differences between TP and ALB. Serum sodium (Na), potassium (K), and phosphorus (P), concentrations were determined using the specific kits of enzymatic colorimetric measuring (Bio-diagnostic Company), and chloride (Cl) was determined using Thiocyanate method (QCA Company). Plasma aldosterone concentrations were measured using a RIA kit produced by Abbott Laboratories (Diagnostics Division, North Chicago, Illinois 60064, USA) (Ekins *et al*., 1972). Serum sodium (Na), potassium (K), phosphorus (P), calcium (Ca), and magnesium (Mg) concentrations were determined using the specific kits of enzymatic colorimetric measuring (Biodiagnostic Company), and chloride (CL) was determined using Thiocyanate method (QCA Company). Estradiol-17 (E_2) and progesterone (P_4) (n= 5 per treatment per parity, thus there were 25 samples per treatment for the whole experiment) were assayed by radioimmunoassay (RIA) using DSL Kits DSL-43100 and DSL-3900, respectively (Diagnostic systems Laboratories Inc, TX, USA) according to Abraham (1977).

Data were analyzed using a factorial experimental design (3 types of water, 2 magnetic treatments) using the general linear model approach defined by SAS software (SAS, 2004). Before the analysis, all percentages were logarithmically transformed to equalize data distribution. Chi-square analyses were used to calculate the conception rate and mortality rate as a percentage.

3. RESULTS

3.1. Quality of water

Physical and chemical analyses of different water types with or without magnetization treatment are presented in Table 1. The data obtained showed that tap water had higher quality than both types of well water (A and B, 4000 ppm and 6000 ppm, respectively) and in all properties such as total dissolved solids (TDS), total hardness (TH), pH, conductivity, K, Na, Mg, Ca, Cl. Furthermore, magnetic field exposure benefited both water types. The magnetic exposure had a smaller influence on tap water and well water in terms of TDS (2.21 vs 0.78 & 0.33%), TH (7.84 vs 2.81 & 4.10%), pH (8.17 vs 3.67 & 4.51%), conductivity 1.22 vs. 0.62 & 0.21%), K (12.53 vs 2.98 & 9.63%), Na (7.52 vs 0.36 & 0.10%), Mg (25.24 vs 1.12 & 7.52%), Ca (10.98 vs 12.50 & 17.57%), and Cl (4.15 vs. 13.52 & 3.60%).

3.2.Growth performance, feed efficiency and water intake

Table 2 illustrates the effect of various treatments on the growth performance of growing female rabbits from weaning to maturity. Female rabbits administered TW showed significant (P < 0.001) increased average BWG, GR, and better feed efficiency (FE), in contrast to water consumption (WC), which has decreased compared to those drank WWA or WWB. Moreover, rabbits that drank the magnetized water regardless of their type obtained higher (P < 0.001) values of BWG, GR, and better FE and lower WC compared to unmagnetized water.

Table 2. Growth performance, feed efficiency and water consumption from weaning to maturity of growing V-line female rabbits as affected by type of water and/or magnetic exposure.

Water type	TR	Growth performance					FI (g/h/d)	FCR (g FI/ kg BG)	WC (ml/d)
		IW (kg)	FW (kg)	ADG (g)	TBG (kg)	GR (%)			
Interaction effects:									
Tap water	(–)	1.052^{a}	3.30^{b}	24.98^{b}	2.25^{b}	213.69^{ab}	149.53^{b}	5.99^{c}	422.47^{c}
	(+)	1.053^{a}	3.48^{a}	26.97^{a}	2.43^{a}	230.48^{a}	157.62^{a}	5.84^{c}	373.77^{d}
Well water (4000 ppm)	(–)	1.052^{a}	3.08^{c}	22.53^{c}	2.03^{c}	192.78^{bc}	139.69^{cd}	6.20^{c}	506.88^{b}
	(+)	1.053^{a}	3.21^{bc}	23.97^{bc}	2.16^{bc}	204.84^{abc}	145.86^{b}	6.09^{c}	435.45^{c}
Well water (6000 ppm)	(–)	1.052^{a}	2.66^{e}	17.87^{e}	1.61^{e}	152.85^{d}	135.8^{d}	7.60^{a}	578.31^{a}
	(+)	1.050^{a}	2.89^{d}	20.44^{d}	1.84^{d}	175.24^{dc}	140.65^{c}	6.88^{b}	555.58^{a}
±SME		0.03	0.05	0.67	0.06	10.52	1.52	0.23	13.71
Water salinity effects:									
Tap		1.05^{a}	3.39^{a}	25.97^{a}	2.34^{a}	222.09^{a}	153.58^{a}	5.91^{b}	398.12^{c}
Well (4000 ppm)		1.05^{a}	3.15^{b}	23.25^{b}	2.09^{b}	198.81^{b}	142.78^{b}	6.14^{b}	471.17^{b}
Well (6000 ppm)		1.05^{a}	2.78^{c}	19.16^{c}	1.72^{c}	164.04^{c}	138.23^{c}	7.24^{a}	566.95^{a}
±SME		0.02	0.03	0.22	0.02	4.35	1.74	0.09	9.69
Magnetization effects:									
(–)		1.05^{a}	3.01^{b}	21.79^{b}	1.96^{b}	186.44^{b}	141.67^{b}	6.50^{a}	502.56^{a}
(+)		1.05^{a}	3.19^{a}	23.79^{a}	2.14^{a}	203.55^{a}	148.04^{a}	6.22^{a}	454.94^{b}
±SME		0.02	0.03	0.22	0.02	3.55	1.42	0.08	7.91
***P* value:**									
Interaction		0.9980	<0.001	0.0001	0.0001	0.0002	<0.0001	<0.0001	<0.0001
Type of water		0.9823	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Magnetic treatment		0.9980	<0.001	0.0010	0.0010	0.0283	<0.001	0.0567	0.0002

[a, b, c and d]: Means within each column with different superscripts are significantly differ (P <0.05).

TR= Treatments; IW= Initial weight; FW= Final weight; ADG= Average daily gain; GR= Growth rate; FI= Feed intake; FCR= Feed conversion ratio; WC= Water consumption.

3.3.Body weight changes of rabbit-does

Table 3 shows that rabbits who drank TW reached maturity at an earlier age and heavier weight than the WW groups, also the same results were obtained when drinking magnetic water (MW) compared to nonmagnetic water (UMW).

Table 3. Body weight changes during mating, pregnancy and suckling period of rabbit-does as affected by type of water and/or magnetic exposure.

Water type	TR	At mating		During pregnancy				During suckling				At weaning
		Weight (kg)	Age (day)	1st wk	2nd wk	3rd wk	4th wk	1st wk	2nd wk	3rd wk	4th wk	
Interaction effects:												
Tap water	(–)	3.30^{b}	133.25^{c}	3.41^{b}	3.65^{b}	3.77^{b}	3.83^{b}	3.55^{b}	3.66^{b}	3.75^{b}	3.92^{b}	4.00^{b}
	(+)	3.48^{a}	130.25^{d}	3.65^{a}	3.76^{a}	3.95^{a}	4.28^{a}	3.85^{a}	3.96^{a}	4.10^{a}	4.23^{a}	4.33^{a}
Well water	(–)	3.08^{c}	134.50^{c}	3.27^{c}	3.52^{cb}	3.56^{c}	3.78^{b}	3.38^{c}	3.52^{c}	3.62^{c}	3.77^{c}	3.82^{c}
(4000 ppm)	(+)	3.21^{bc}	136.50^{b}	3.33^{b}	3.49^{c}	3.58^{c}	3.71^{b}	3.44^{c}	3.58^{bc}	3.69^{c}	3.88^{c}	3.92^{cb}
Well water	(–)	2.66^{e}	140.08^{a}	2.88^{d}	3.01^{d}	3.11^{d}	3.22^{c}	3.04^{d}	3.09^{e}	3.19^{d}	3.28^{d}	3.35^{e}
(6000 ppm)	(+)	2.89^{d}	142.00^{a}	3.06^{cd}	3.46^{c}	3.56^{c}	3.65^{bc}	3.32^{cd}	3.42^{d}	3.55^{c}	3.62^{cd}	3.72^{d}
±SME		0.02	0.05	0.04	0.04	0.03	0.05	0.05	0.05	0.06	0.06	0.05
Water salinity effects:												
Tap		3.39^{a}	131.75^{c}	3.53^{a}	3.71^{a}	3.86^{a}	4.06^{a}	3.70^{a}	3.81^{a}	3.93^{a}	4.08^{a}	4.17^{a}
Well (4000 ppm)		3.15^{b}	135.50^{b}	3.30^{b}	3.51^{b}	3.57^{b}	3.75^{b}	3.41^{b}	3.55^{b}	3.66^{b}	3.83^{b}	3.87^{b}
Well (6000 ppm)		2.78^{c}	141.04^{a}	2.97^{c}	3.24^{c}	3.34^{c}	3.44^{c}	3.18^{c}	3.26^{c}	3.37^{c}	3.45^{c}	3.54^{c}
±SME		0.03	0.48	0.03	0.03	0.02	0.03	0.03	0.04	0.04	0.04	0.04
Magnetization effects:												
(–)		3.01^{b}	135.94^{a}	3.19^{b}	3.39^{b}	3.48^{b}	3.61^{b}	3.32^{b}	3.42^{b}	3.52^{b}	3.66^{b}	3.72^{b}
(+)		3.19^{a}	136.25^{a}	3.35^{a}	3.57^{a}	3.70^{a}	3.88^{a}	3.54^{a}	3.65^{a}	3.78^{a}	3.91^{a}	3.99^{a}
±SME		0.03	0.39	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03
***P* value:**												
Interaction		<0.001	0.0012	0.6499	0.0508	0.0089	0.015	0.0008	0.014	0.0106	0.0071	0.0022
Type of water		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Magnetic treatment		<0.001	0.582	0.0014	0.0559	0.1667	0.4509	0.9014	0.5213	0.7732	0.5594	0.3315

$^{a, b,c,d \text{ and } e}$**:** Means within each column with different superscripts are significantly different (P <0.05). TR= Treatments; wk: week

Body weight at mating, during pregnancy and suckling were significantly ($P< 0.001$) influenced by water type and magnetic exposure, showing that body weight changes of does was increased due to magnetic exposure compared to those drank unmagnetized for different water types. BW reached heavier weight at late period of experiment (at weaning) in G1 and G2 (TW groups), while the light weight was found in WWB groups.

3.4.Reproductive performance of rabbit does

Reproductive traits of experimental rabbit-does are presented in Table 4. The results for number of services per conception (NS/C), conception rate (CR), litter size at birth (LSB), litter size at weaning (LSW) and mortality rate (MR) of weaning bunny are presented in Table 4. There was significant ($P< 0.05$) interaction between water type and magnetic treatment on previous studied traits. Magnetic exposure groups had a lower ($P> 0.05$) NS/C and higher ($P< 0.05$) CR than unexposed groups. Also, TW groups had a greater ($P< 0.05$) LSB and LSW than WW groups, but lower MR. However, magnetic exposure insignificant ($P> 0.05$) increased LSB and significant ($P< 0.05$) increased LSW while decreased MR significantly.

Table 4. Reproductive performance of rabbit-does as affected by type of water and/or magnetic exposure.

Water type	TR	NS/C	CR (%)	Litter size (n.)		
				LSB	LSW	MR (%)
Interaction effects:						
Tap water	**(–)**	1.25^{b}	83.00^{a}	6.00^{a}	4.25^{a}	29.17^{a}
	(+)	1.00^{b}	100.00^{a}	7.25^{a}	5.75^{a}	20.69^{a}
Well water (4000 ppm)	**(–)**	1.08^{b}	68.75^{b}	5.42^{a}	3.33^{ab}	38.56^{a}
	(+)	1.33^{b}	75.00^{ab}	5.17^{ab}	3.83^{a}	25.92^{a}
Well water (6000 ppm)	**(–)**	2.19^{a}	66.67^{b}	3.33^{c}	1.33^{c}	60.06^{a}
	(+)	1.67^{ab}	68.75^{b}	4.25^{bc}	2.58^{ab}	39.29^{a}
±SE			0.25	18.8	0.54	12.42
Water salinity effects:						
Tap		1.13^{b}	91.50^{a}	6.63^{a}	5.00^{a}	24.53^{a}
Well (4000 ppm)		1.21^{b}	71.88^{b}	5.30^{a}	3.58^{a}	32.39^{ab}
Well (6000 ppm)		1.93^{a}	67.71^{b}	3.79^{b}	1.96^{b}	48.42^{b}
±SE		0.17	13.28	0.48	0.57	8.92
Magnetization effects:						
(–)		1.51^{b}	72.81^{a}	4.92^{a}	2.97^{b}	42.60^{a}
(+)		1.33^{a}	81.25^{a}	5.58^{a}	4.05^{a}	28.63^{b}
±SE		1.14	11.08	0.40	0.55	7.03
***P* value:**						
Interaction		0.0323	0.0498	0.045	0.049	0.037
Type of water		0.0301	0.0464	<0.0001	0.042	0.016
Magnetic treatment		0.0150	0.9642	0.262	0.035	0.011

a, b, and c: Means within each column with different superscripts are significantly different ($P<0.05$). TR= Treatments; NS/C= No. of services/conception; CR= Conception rate; LSB= Litter size at birth/doe; LSW= Litter size at weaning/doe; MR= Mortality rate at weaning

3.5.Ovarian Hormones

Ovarian hormones (E_2, P_4 and E_2/P_4 ratio) are shown in Table 5. There was significant ($P< 0.01$) interaction between water type and magnetic exposure on the E_2 and P_4 and their ratio. TW and magnetic exposure had higher ($P< 0.001$) serum E_2 and P_4 than well water and non-exposure water.

3.6.Productive performance of rabbit-does

Table 6 provided data on productive performance of rabbit-does such as bunny litters growth from birth to weaning, milk yield and milk conversion ratio as affected by water type

Table 5. Ovarian hormones of rabbit-does as affected by type of water and/or magnetic exposure.

Water type	TR	Ovarian hormones (ng/ml)		
		E_2	P_4	E_2 / P_4
Interaction effects:				
Tap water	(–)	0.2036^{b}	0.6033^{b}	0.3375^{bc}
	(+)	0.2542^{a}	0.6941^{a}	0.3662^{b}
Well water (4000 ppm)	(–)	0.1550^{d}	0.3362^{d}	0.4610^{a}
	(+)	0.1705^{c}	0.5076^{c}	0.3359^{bc}
Well water (6000 ppm)	(–)	0.1231^{f}	0.3317^{d}	0.3711^{b}
	(+)	0.1412^{e}	0.4771^{c}	0.2959^{c}
±SE		0.004	0.01	0.02
Water salinity effects:				
Tap		0.2289^{a}	0.6487^{a}	0.3529^{b}
Well (4000 ppm)		0.1628^{b}	0.4219^{b}	0.3859^{a}
Well (6000 ppm)		0.1322^{c}	0.4045^{b}	0.3268^{b}
±SE		0.003	0.01	0.01
Magnetization effects:				
(–)		0.1606^{b}	0.4237^{b}	0.3790^{a}
(+)		0.1886^{a}	0.5596^{a}	0.3370^{b}
±SE		0.002	0.01	0.01
***P* value:**				
Interaction		0.0013	0.0144	0.0009
Type of water		<0.0001	<0.0001	<0.0001
Magnetic treatment		<0.0001	<0.0001	0.001

[a, b, and c]**:** Means within each column with different superscripts are significantly different ($P < 0.05$). TR= Treatments;; E_2= Estradiol; P_4= Progesterone.

and magnetic exposure. There was a significant (P< 0.05) interaction between water type and magnetic treatment on the mentioned above traits as rabbits consumed magnetized water. Their offspring had higher (P< 0.05) BW at birth, at weaning, and BW gain as well as higher (P< 0.05) milk yield and better (P< 0.05) milk conversion ratio than unexposed counterparts. Two types of WW (A and B) groups had a lower weight at birth, at weaning, milk yield and milk conversion ratio. On the other side, magnetic treatment had a positive (P< 0.05) impact on the aforementioned groups regardless of water type.

3.7.Serum protein profile, and liver enzymes

Effect of water type with or without magnetic exposure on serum protein profile, and liver enzymes are presented in Table 7. The findings revealed a significant (P < 0.05) interaction between type of water (TW, WWA or WWB) and magnetic exposure (with or without) on protein profile (TP, ALB, & GLO), and liver enzymes (AST, ALT, and its ratio). TW increased TP, ALB, and GLO levels but decreased AST, and ALT levels compared to WWA and WWB. Also, magnetized water regardless of its type (TW WWA or WWB) increased serum protein, ALB, and ALB/GLO ratio, but reduced globulin level, and liver enzymes (AST & ALT) and its ratio (AST/ALT) compared to non-magnetized water.

3.8.Blood serum ions and aldosterone hormone

Table 8 indicated that there was a significant (P < 0.01) interaction between water type and magnetic treatment on blood serum ions such as Na, K, Cl & P and ALD hormone. Treated groups consumed TW had significantly (P < 0.01) lower Na and Cl, calcium (Ca) and magnesium (Mg), while WW groups had significantly lower values of K and P. Magnetic treatment regardless water types increased (P < 0.001) K, and ALD and the response depends on water type and reduced (P < 0.001) Na, Cl and P compared to non-magnetized water.

Table 6. Bunny weights, milk yield and milk conversion ratio of rabbit-does as affected by type of water and/or magnetic exposure.

Water type	TR	Bunny weight (g)				MY (g)	MCR (g milk / g gain)
		N.	BWB	BWW	BTG		
Interaction effects:							
Tap water	(–)	4.25[a]	51.00[a]	567.00[a]	516.00[a]	5420.11[a]	2.47[bc]
	(+)	5.75[a]	61.63[a]	673.25[a]	611.63[a]	6210.23[a]	1.77[c]
Well water (4000 ppm)	(–)	3.33[ab]	43.95[ab]	517.70[a]	471.63[ab]	5060.54[a]	3.22[b]
	(+)	3.83[a]	46.07[a]	496.45[a]	452.51[ab]	5760.74[a]	3.32[b]
Well water (6000 ppm)	(–)	1.33[c]	28.31[c]	340.05[b]	311.75[b]	2100.24[c]	5.07[a]
	(+)	2.58[ab]	36.13[bc]	418.25[ab]	382.13[b]	4670.35[b]	4.74[a]
±SME		0.54	0.14	15.64	11.25	23.65	0.47
Water salinity effects:							
Tap		5.00[a]	56.31[a]	620.13[a]	563.81[a]	5815.17[a]	2.12[c]
Well (4000 ppm)		3.58[a]	45.01[ab]	507.08[a]	462.07[b]	5410.64[a]	3.27[b]
Well (6000 ppm)		1.96[b]	32.22[b]	379.15[b]	346.94[c]	3385.30[b]	4.90[a]
±SME		0.57					
Magnetization effects:							
(–)		2.97[b]	41.79[b]	474.92[a]	433.13[b]	4193.63[b]	3.59[a]
(+)		4.05[a]	47.23[a]	529.32[a]	482.09[a]	5547.11[a]	3.28[a]
±SME		0.55					
***P* value:**							
Interaction		0.049	0.047	0.008	0.030	0.046	0.035
Type of water		0.042	0.007	0.029	0.021	0.022	0.019
Magnetic treatment		0.036	0.020	0.821	0.050	0.042	0.146

[a, b, and c]: Means within each column with different superscripts are significantly different ($P < 0.05$). TR= Treatments; BWB= Bunny weight at birth; BWW= Bunny weight at weaning; BTG= Bunny total gain; MY= milk yield; MCR= milk conversion ratio.

4. DISCUSSION

There are many assumptions regarding magnetically processed water, like passing water via a magnetic field will enhance water characteristics such as chemical, physical, and bacteriological (Rajan *et al.,* 2017). The study hypothesis was verified by poorer WW quality and the rabbit-does performance on WW vs. the performance of those drinking TW. Also, WW was more sensitive to the magnetic treatment than TW. The findings of this investigation showed that WW was of worse quality than TW, but there was an enhancement in water quality when subjected to a magnetic treatment, with significant alterations in TDS, conductivity, pH, total hardness, and dissolved elements. These results are agreement with reported by El-Hanoun *et al*. (2013) and Helal *et al*. (2022) who observed that exposed water to a magnetic field regardless of its type improved its quality by changing the concentration of most elements and increasing conductivity. Although tap water had higher quality than well water, there was an enhancement in their quality when exposed to the magnetic field. Moreover, exposing water to a magnetic field affects its qualities, causing it to become more electrified, active, soft, and slightly high in alkalinity and free of pathogens, meeting the needs for poultry water quality (Mg-Therapy, 2000). The pH of magnetized water may be 7.8, which does not allow cancer cells to grow in an alkaline medium compared to non-magnetized water, which has a neutral acidity of about 7 (Lam, 2001). Higher salty content in well water, as seen in Table 1, could be attributable to a higher level of dissolved salts which are related to electrical conductivity. This could be explained by an increase in organic matter from wastewater or chemical fertilizers like nitrates and phosphates, which boost algal growth. So, Tkachenko and Semyonova (1995) reported that exposed water to the magnetic treatment acquires a more homogeneous and

Table 7. Serum protein profile, and liver enzymes of rabbit-does as affected by type of water and/or magnetic exposure.

Water type	TR	Protein profile (g/dl)				Liver enzymes (IU/L)		
		TP	ALB	GLO	ALB/GLO	AST	ALT	AST/ALT
Interaction effects:								
Tap water	(–)	5.75[b]	3.66[b]	2.09[a]	1.75[b]	48.00[e]	32.50[f]	1.48[a]
	(+)	6.18[a]	4.09[a]	2.09[a]	1.96[a]	55.50[d]	42.00[e]	1.32[b]
Well water	(–)	4.68[d]	2.90[d]	1.78[b]	1.63[b]	132.50[b]	106.00[c]	1.25[bc]
(4000 ppm)	(+)	4.99[c]	3.40[c]	1.59[d]	2.14[a]	95.00[c]	89.00[d]	1.07[e]
Well water	(–)	4.28[e]	2.71[e]	1.57[d]	1.73[b]	149.00[a]	127.00[a]	1.17[cd]
(6000 ppm)	(+)	4.61[d]	2.94[d]	1.67[bc]	1.76[b]	135.50[b]	119.00[b]	1.14[d]
±SE		0.07	0.04	0.06	0.06	1.94	2.16	0.03
Water salinity effects:								
Tap		5.96[a]	3.87[a]	2.09[a]	1.86[a]	51.75[c]	37.25[c]	1.39[a]
Well (4000 ppm)		4.83[b]	3.15[b]	1.68[b]	1.88[a]	113.75[b]	97.50[b]	1.17[b]
Well (6000 ppm)		4.44[c]	2.83[c]	1.62[b]	1.75[b]	142.25[a]	123.00[a]	1.16[b]
±SE		0.049	0.03	0.04	0.04	1.37	1.52	0.02
Magnetization effects:								
(–)		4.09[b]	3.09[b]	1.81[a]	1.71[b]	109.83[a]	83.33[a]	1.32[a]
(+)		5.26[a]	3.48[a]	1.78[b]	1.96[a]	95.33[b]	88.50[b]	1.08[b]
±SE		0.04	0.02	0.03	0.04	1.12	1.24	0.02
***P* value:**								
Interaction		0.0079	0.0411	0.0051	<0.0001	<0.0195	<0.0001	<0.0001
Type of water		<0.0001	<0.0001	0.0130	<0.0001	<0.0001	<0.0001	0.0002
Magnetic treatment		<0.0001	<0.0061	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

[a, b, c, d and e]**:** Means within each column with different superscripts are significantly different (*P* <0.05). TR= Treatments; AST= Aspartate Aminotransferase; ALT= Alanine Aminotransferase.

finer pattern. It also raises the fluidity and dissolvability of numerous elements such as vitamins and minerals (Kronenberg, 1985), thus enhancing the biological function of solutions, beneficially impacting the performance of plants, animals, and humans (Al-Mufarrej *et al*., 2005).

Growth performance such as BWG and GR, FI, and FCR were all reduced and WC was increased in rabbit-does drank both types of well water compared to those drank tap water, and the impairment in BWG and FI amounted to 10.68 & 26.50 and 7.03 & 9.99%, in WWA and WWB, respectively. Thus, the reduction in FI may be responsible for 34.18 & 62.28% of the decrease in BWG increase, whereas poor FE could account for the rest of the impairment in BWG (65.82 & 37.72%). There was a significant ($P < 0.001$) interaction between type of water and magnetic exposure on BWG, GR, FCR and WC. These results are agreement with reported by El-Hanoun *et al*. (2013), Attia *et al*. (2015) and Helal *et al*. (2022) who observed that rabbits consumed magnetized TW or WW gained much more BW, increased growth rate, decreased feed intake and enhanced significantly FCR. Both TW groups consumed more water when using than WW groups. Also, groups with magnetic treatment consumed much more water. Moreover, Yacout *et al*. (2015) demonstrated that magnetized water has a positive effect on rabbit bucks' feed efficiency. However, Mahmoud, *et al*. (2015) reported that there were no significant changes in average feed intake between the groups exposed to 1200 and 3600 Gauss of magnetic compared to a non-magnetized group. According to Ayyat *et al*. (1991), the decrease in rabbit's BWG given high doses of salt in water might be ascribed to a loss in body fat. The reduction in BWG of ruminants consuming saline water was related to rising glucocorticoid levels (Holmes *et al*., 1961; Kii and Dryden, 2005). They also stated that consuming saline water lowered the digestion,

Table 8. Minerals parameters and aldosterone hormone of rabbit-does as affected by type of water and/or magnetic exposure.

Water type	TR	Minerals parameters				ALD (Pg/ml)
		Na (mmol/l)	K (mmol/l)	Cl (mg/dl)	P (mg/dl)	
Interaction effects:						
Tap water	(–)	116.00[e]	5.07[b]	80.95[d]	4.39[a]	32.07[b]
	(+)	96.00[f]	5.44[a]	74.95[e]	4.28[b]	36.45[a]
Well water (4000 ppm)	(–)	147.50[c]	4.70[d]	96.32[c]	4.01c[d]	23.82[c]
	(+)	139.00[d]	4.91[c]	92.59[c]	4.06[c]	29.10[b]
Well water (6000 ppm)	(–)	170.00[a]	4.38[e]	126.72[a]	3.95[d]	16.43[d]
	(+)	158.50[b]	4.61[d]	107.29[b]	3.75[e]	20.82[c]
±SE		1.54	0.05	1.61	0.01	1.34
Water salinity effects:						
Tap		106.00[c]	5.25[a]	77.95[c]	4.34[a]	34.27[a]
Well (4000 ppm)		143.25[b]	4.80[b]	94.46[b]	4.03[b]	26.46[b]
Well (6000 ppm)		164.25[a]	4.49[c]	117.00[a]	3.85[c]	18.63[c]
±SE		1.09	0.04	1.14	0.02	0.95
Magnetization effects:						
(–)		144.50[a]	4.72[b]	101.33[a]	4.12[a]	24.11[b]
(+)		131.17[b]	4.98[a]	91.61[b]	4.03[b]	28.79[a]
±SE		0.89	0.93	0.93	0.01	0.78
***P* value:**						
Interaction		0.0043	0.0015	0.0002	0.0002	0.0088
Type of water		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Magnetic treatment		<0.0001	<0.0001	<0.0001	0.0003	0.0005

[a, b, c, d and e]**:** Means within each column with different superscripts are significantly different ($P < 0.05$). TR= Treatments; Na= Sodium; K= Potassium; Cl= Chloride; P= Phosphorus; ALD= Aldosterone.

absorption, and use of several nutrients, causing a disruption in protein and lipid metabolism and, as a result, reduced nitrogen absorption.

Furthermore, the reduction in BW caused by consuming saline water was attributed to a decrease in both FI and protein synthesis due to lower thyroid hormones concentrations (Marai and Habeeb, 1994; Mohamed *et al*., 2017).

The current study found that the quality of well water had a detrimental effect on productive and reproductive performance, physiological response, ovarian hormones, blood constituent, and growth of rabbit-does form parturition till weaning their offspring, with decreased ALD hormone than those on tap water. Magnetic exposure enhanced reproductive performance of does such as number of services/ conception, conception rate, litter size at birth and weaning and mortality rate at weaning. the improvement in offspring performance was accompanied by greater milk yield and milk conversion ratio. The enhancement of reproductive performance of rabbit-does consumed magnetic water were coincided with improving health status of does as pointed by reducing liver enzymes and increasing serum protein profile and ovarian hormones. The current findings are in agreement with those reported by El-Hanoun *et al*. (2013) and Attia *et al*. (2013). The resulting impacts are possibly related to the effect of the magnetic exposure and the enhanced activity of metabolic processes (El-Kholy *et al*., 2008). Serum biomarkers can be used to assess nutritional and physiological health (Mahmoud *et al*., 2015). One explanation for the improved biological efficiency could be serum proteins, liver enzymes, serum ions, and ALD and ovary hormones based on the influence of magnetic exposure on water mineral solubility that promotes nutrient transfer to animal cells by increasing membrane permeability. Thus, nutrient absorption and benefit from it because water is the medium for all biological and metabolic responses. Magnetic exposure also has been shown to enhance water quality, minimize lime accumulation in vessels, and reduce microbial count (Skeldon, 1990; Sargolzehi *et al*., 2009). Poor water quality has been demonstrated to have an impact on animal performance resulting in more health issues. (El-Hanoun *et al*., 2013; Attia *et al*., 2013). The enhanced performance of rabbit-does and their litter that drank magnetic water confirm the carryover influence of water type and magnetic procedures. This might be attributed to enhanced does' immunity and health, as previously noted. Similar findings were reported by El-Hanoun *et al*. (2013), Attia *et al*. (2013 & 2015) and Helal *et al*. (2022). The detrimental impact of well water on pregnant does and their BW changes pre- and post-parturition was confirmed by reducing milk yield and milk conversion ratio. These results are consistent with those published by El-Hanoun *et al*. (2013) and Attia *et al*. (2013). Reduction of milk production could be due to impairment feed efficiency (FE) and impair immunity (Ghazalah and Ali, 2008). Thus, the impairment FE of the both types of WW groups in the current study could be attributed to the reduction in the pathogen microflora and thus impaired gastrointestinal ecology and/or decreased nutrients digestion. The lowering of milk yield might be attributed to the non-healthy effect of WW administration and The concomitant effect between succinate and acetate on intestinal microflora, which results in impairment FE and milk production (Abo El-Nor and Kholif, 2005). Also, serum energy markers (glucose) levels and/ or thyroid hormones were greater in the magnetized TW group (Helal *et al.,* 2022), indicating that enhanced feed intake provided adequate energy to sustain increased milk production. (Stella *et al.,* 2007). Collier *et al*. (1984) suggested that the pituitary thyroid pathway is a key physiological agent regulating the processes of metabolism and milk release. Thyroid hormones collaborate with other hormones to support mammary gland growth and development as well as lactation maintenance. Thyrotropin-releasing hormone or Thyroxin injection boosts milk output in cows moderately. (Lapierre *et al*., 1990).

5. CONCLUSION

Passing well water through a magnetic field may be an important useful tool for improving its quality and reduce its negative effects on reproductive performance, liver function, and ovarian efficacy of rabbit-does. This could prove beneficial in limited water locations where well water is the main source of drinking water.

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الملخص العربي

أداء اناث الأرنب بعد شربها أنواع مختلفة من الماء تعرضت لمجال مغناطيسي

أحمد هلال محمود[١]، ايه جابر عبد العظيم[١]، ناجى حامد ابراهيم[١] و محمود ياسين محمد[٢]

[١]قسم النتاج الحيواني والداجني – كلية الزراعة – جامعة بنى سويف

[٢]معهد بحوث الانتاج الحيوانى – معهد البحوث الزراعية

تهدف الدراسة الحالية إلى معرفة تأثير أنواع مختلفة من المياه، مثل مياه الآبار (WW) ومياه الصنبور(TW)، بعد المعالجة المغناطيسية بحوالي ١٠٠٠٠ جاوس على أداء اناث الأرانب. تم تقسيم ثمانية وأربعين انثى مفطومة من سلالة ارانب V–line إلى ست مجموعات (٨ لكل مجموعة). شربت المجموعتان الأولى والثانية ماء الصنبور سواء تعرضت المياه للمغنطة MTW أم لا TW . استخدمت المجموعات الأخرى مياه الآبار باستخدام نفس الطريقة فاستخدمت المجموعتان الثالثة والرابعة مياه تصل ملوحتها الى ٤٠٠٠ جزء في المليون (MWWA مقابل WWA) والمجموعتان الخامسة والسادسة استخدمت مياه تصل ملوحتها الى ٦٠٠٠ جزء في المليون (MWWB مقابل WWB) .أشارت النتائج إلى أن المغنطة كان لها تأثير أعلى علىWW، سواء ٤٠٠٠ أو ٦٠٠٠ جزء في المليون مقارنة بمجاميعTW. كما اثرت عملية المغنطة من اداء الارانب فانخفض استهلاك العلف بشكل ملحوظ (P <0.001) في حين تحسن متوسط الزيادة اليومية ومعدل النمو ونسبة التحويل الغذائي بشكل ملحوظ (P <0.001). خفضت مياه الابار معنويا (P <0.001) حجم المواليد ووزن المواليد عند الولادة والفطام وإنتاجية الحليب مقارنة بـ مياه الصنبور. كما خفضت معنويا (P <0.001) نسبة البروتين فى الدم وإنزيمات الكبد وهرمونات المبيض وهرمون الألدوستيرون ولكنها زادت نسبة الصوديوم والكلوريد فى الدم. عند تعريض الماء للمعاملة المغناطيسية تم تحسين حجم المواليد ووزن المواليد عند الولادة والفطام وإنتاج الحليب وزيادة نسبة التحويل اللبني وتحسين مستويات إنزيمات الكبد وهرمونات المبيض مقارنة بالمياه غير الممغنطة. إن استخدام المغنطة خاصة في المياه المالحة يقلل من الآثار الضارة للملوحة ويحسن جودة المياه.