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Effect of magnetic water on the performance of lactating goats

Summary

This work was aimed to test the responses of zaraibi goats consumed magnetic water (field of ≈1200 and 3600 gauss) on rumen fermentation, milk and labneh yield and their components. Blood picture and antioxidant status were also studied. Fifteen lactating Zaraibi does (post weaning) were randomly divided into three equal groups (5 does each). First group, were drank tap water and regarded as control group, second and third groups were drank magnetic treated water with 1200 and 3600gauss, respectively. While nine zaraibi bucks were used in three digestion trials. For rumen fermentation trials three does fitted with permanent rumen fistula were used. All groups of goats were provided free access to the water and fed the same ration.[1]

Results indicated that:

a. There was an improvement in water quality when exposed to the magnetic field;
b. Magnetic water significantly increased feeding values, nitrogen utilization, VFA's concentration, ruminal bacteria numbers and their activities and microbial protein (MP) syntheses, the highest values were recorded at the used level of 3600gauss;
c. pH value, ammonia-N concentration and methane production was decreased with magnetic water;
d. DM and NDF with magnetic water were more effective degradability, while no significant different in CP degradability among groups;
e. Third group (T_2) had significantly increased feed intake and water consumption; it had significantly yielded more milk, 4% FCM, milk fat and protein than other groups;
f. Chemical composition and organoleptic properties of labneh were increased with magnetic groups;
g. some hematological and biochemical (glucose, total protein, albumin and globulin) parameters were significantly increased with magnetized water, while cholesterol and urea-N concentrations, AST and ALT were significantly decreased and
h. Magnetic water resulted in higher antioxidant compared to that drank unmagnetic water.

In conclusion, magnetic treatment could improve water quality and consumption, feeding value, ruminal fermentation, blood picture, antioxidant status and hence milk and labneh yields especially with 3600gauss.

Keywords: magnetic water, digestibility, rumen fermentation, blood picture, antioxidant status, milk production, labneh manufacturing, zaraibi goats

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Yacout MH, Hassan AA, Khalel MS, Shwerab AM, Abdel-Gawad EI, Abdel-kader YI
Animal Production Research Institute, Agriculture Research Center, Egypt

Correspondence: Helmy Yacout, Animal Production Research Institute, Agriculture Research Center, Dokki, Giza, Egypt, Email helmy_yacout@yahoo.com

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Introduction

Water quality is necessary for animal production as water is the fuel of life; it transports fluids and nutrients through the blood, maintains the integrity of cell structure and regulates body temperature.[2,3] Sargolzehi et al.[4] refer that, the first component being used in producing milk by mammals is water, which is named as the second essential nutrient for lactating dairy cattle. In literature, the magnetic technology was investigated in the plant fields, but little attention was given to its roles in animal reproductive and production application.[5,6] The principle of magnetic technology depends on a moving electric charge in the ion form and the magnetic field.[7] Contact of water with a permanent magnet for a considerable time produced magnetic charges and magnetic properties. Such magnetically treated water can decrease microbial load and improve the immune system.[8] Exposing of water to strong magnetic field affected minerals content of water and its effects depended on the strength of magnetic field and exposure time. Nowadays, the use of magnets to improve water quality is of significant interest due to low cost compared to chemical and physical treatments. In this regard, exposing water to a magnetic field causes an increase in solubility of calcium salts so that avoids from lame-scale depositing in pipes and also cleans pipes from lamescales being deposited in the past.[9] Lin[10] mentioned that there is a change in mineral contents of water by magnetizing that causes them to pass the biological membranes more easily.

Ma et al.[11] presented the possibility that magnetic water can prevent aging and fatigue by increasing the cell membrane permeability. Also, Buyukuslu et al.,[12] indicated that activity of superoxide dismutase was increased in magnetic field.[12] Water magnetization changes water properties which becomes more energized, active, soft and high pH toward slight alkaline and free of germs,[13] also Al-Mufarrej et al.,[6] mentioned that, water solution passes through magnetic field acquire finer and more homogeneous structures, which increases the fluidity, dissolving capability for various constituents like minerals and vitamins and consequently improves the biological activity of solutions, affecting positively the performance of animals and plants. Physics shows that water change its weight under the influence of magnetic fields. More hydroxyl (OH-) ions are created to form alkaline molecules, and reduce acidity, for this reason cancer cells do not survive well in an alkaline environment.[8] Water resources and quality has been shown to influence animal performance, limit the extension of animal production and increase health threat.[3,14,15] Some researches indicated that magnetic water resulted in better efficiency in agricultural products.[16,17]

In animal husbandry, Lin & Yotvat[10] reported that magnetic drinking water caused increase milk production, mutton, and wool in sheep not only that, but more weight gain in geese and egg production and hatchability in turkey can be achieved. Also, increasing in milk yields in dairy cows;[10] dairy ewes.[18] Khlil et al.[19] concluded that milk sterilization might perform using magnetic field application. Moreover, it is considerable to more beneficial effects for rumen ecosystem and ruminal fermentation parameters.[20] On the other hand, a contradictory results were reported by Patterson & Chestnutt[21] and Sargolzehi et al.,[4] they showed that magnetic water did not positively affect animal and poultry performance. So, due to the few publications for evaluating the effect of using magnetic water with dairy animal and hence milk component changes, the aim of this study was to find the effect consuming magnetic water on water consumption, rumen fermentation, antioxidant status, milk and blood components of lactating goats and labneh yield and its properties.

Materials and methods

The experimental work of the present study was conducted at Noubaria Experimental Station, affiliates Animal Production Research Institute, Agriculture Research Center.

Preparation of Magnetically treated Water (MTW)

Two types of permanent magnets were used for conditioning of water by using what is called Aqua Correct unit (Magnetic water softeners and Conditioners, Blue Goose Sales, 200S Duane Ct, Post Falls ID 83854, USA). First with 1200gauss magnet and second 3600Gauss magnet, which were produced for pipe water conditioning. The strength of the magnet was measured by a gauss meter before the initiation and after the termination of the experiment at Application Laboratory, City for Scientific Research and Biotechnology, Japanese University, Egypt.

Water quality

Physiological properties of ordinary and magnetically treated water were determined according to H.M.S.O.[22] Total bacteria count was determined according to Clesceri et al.[23] Quantitative determination of macro elements of minerals in water were measured using Atomic Absorption Spectrometer (Perkin Elemer, model 10LOB) according to Hegheduş-Mîndru et al.[24]

Diet nutrient profile

Table 1 illustrated the chemical composition of experimental concentrate feed mixture (CFM) and roughages {whole corn silage (WCS) and shopped rice straw (RS) (1:1, WCS: RS, on DM basis)} used in the experiment. CFM consists of 35% yellow corn, 10% soybean meal, 18% wheat bran, 8% rice bran, 20% undecorticated cotton seed meal, 5% molasses, 2.5% limestone, 1% salt, 0.5% mineral mixtures.

Table 1 Chemical analyses and fiber fraction of CFM, WCS and RS (% on DM basis)

Items	CFM	WCS	RS
Chemical analysis			
OM	90.21	90.17	84.88
CP	15.56	8.57	3.83
CF	11.83	27.42	36.79
EE	2.88	3.02	1.61
Ash	9.79	9.83	15.12
NFE	59.94	51.16	42.65
Fiber fractions			
NDF	50.11	53.25	66.84
ADF	33.06	34.65	47.25
ADL	4.21	5.44	11.34
Hemi-Cellulose	17.05	18.6	19.59
Cellulose	28.85	29.21	35.91

Digestibility and nitrogen balance trials

Digestibility and nitrogen balance trials were carried out using nine zaraibi bucks (48±1.50kg, a live body weight) and divided into three groups (C, T_1 and T_2; three bucks each). Each group was subjected to a different treatment: First group (C, control) with ordinary tab water; second group consumed water treated with 1200gauss (T_1) and left to have third group had treated water with 3600gauss (T_2). Each trial lasted for 42days; the first 35days as a preliminary period, followed by 7days for feces and urine collection. Animals were offered roughage *ad libitum* twice a day at 8.00 and 16.00 plus restricted amount of CFM to cover 50% of protein requirements according to NRC.[1] Bucks were provided with fresh magnetic water treatment every 12hours according the instructions of the magnetic manufacturer. Water consumption was recorded, and water tanks were filled twice daily. Chemical composition of feeds, feces and urine was determined according to AOAC.[25] Cell wall was analyzed for neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) using Tecator Fibretic system. Hemicellulose and cellulose were determined by difference according to Van Soest.[26]

Rumen fermentation and In situ trials

Three ruminally-canulated zaraibi does were used for rumen fermentation and *in situ* trials. Rumen samples were withdrawn before feeding and 1, 3 and 6hrs after feeding for *in vitro* incubation using the zero rate techniques as described by Carrol and Hungate.[27] Ruminal pH value measured using digital pH meter (Orian 680). Ammonia-N was carried out using MgO distillation method,[28] while total VFA's were determined by steam distillation as described by Warner.[29] Total bacteria count was carried out according to Difco[30] microbial nitrogen synthesis in the rumen according to the method of Makkar et al.,[31] using tungstic acid. Nylon bags technique[32] was used to determine DM, NDF and CP degradability for ration. Two polyester bags (7×15cm) with pore size of 45µm were used for each incubation time. Approximately 5g of air-dried ration (ground to 2 mm) were placed in each bag. Bags were incubated in the rumen of each doe and withdrawn after 3, 6, 12, 24, 48, 72 and 96h. After the bags were withdrawn from the rumen, they were rinsed in tap water until the water became clear, then they were squeezed gently. Microorganisms attached to the residual sample were eliminated by freezing at - 20°C.[33] Zero-time washing losses (a) were determined by washing 2 bags in running water for 15min. The degradation kinetics of DM, NDF and CP were estimated (in each bag) by fitting the disappearance values to the equation $P=a+b(1-e^{-ct})$ as proposed by Ørskov and McDonald,[34] where P represents the disappearance after time t. Least-squares estimated soluble fractions are defined as the rapidly degraded fraction (a), slowly degraded fraction (b) and the rate of degradation (c), respectively. The effective degradability (ED) were estimated from the equation cited by McDonald,[35] $ED = a+bc/(c+k)$, where k is the out flow rate.

Methane production determination

The *in vitro* gas production (GP) assay was adapted to a semi-automatic system[36] using a pressure transducer and data logger (GN200) for measuring the gas produced in 120ml serum bottles incubated at 39°C. Ground samples (0.3g) were incubated in 45ml of diluted rumen fluid.[37] Once filled, all the bottles were closed with rubber stoppers shaken and placed in the incubator at 39°C. The bottles were shaken manually after the recording of the gas headspace pressure at 6, 12 and 24h incubation using a pressure transducer.[38] Methane determination using gas chromatography equipped. Methane production at the end of incubation period was estimated from the volume of gas and the gas composition data as "$CH_4=[GP+HS]\times Conc$"; where CH_4 is the volume (ml) of methane, GP is the volume (ml) of gas produced at the end of the incubation, HS is the volume (ml) of the headspace in the serum bottle and Conc is the percentage of methane in the gas sample analyzed.[39]

Feeding experiment

Fifteen lactating Zaraibi does (post weaning) in the 2nd and 3rd season of lactation, aging 2.5-3.5years with 36.25Kg in average body weights were randomly divided into three equal groups, (5 does each) for experiment period of 60days in randomized complete block design.[40] Animals were offered roughage *ad libitum* twice a day at 8.00 and 16.00 plus restricted amount of CFM to cover 50% of protein requirements according to NRC.[1] Does were provided with fresh magnetic water treatment every 12hours, water consumption was recorded. Milk yield was individually recorded on two successive days, milk samples were collected twice daily for 4times in the 60days through the collection period from all goats according to Galatov.[41] Milk samples (about 0.5% of total milk produced) were taken biweekly from does of all groups during lactation. Milk samples were chemically analyzed for total solid (TS), protein, fat and ash according to AOAC[25] while lactose was calculated by difference.

Preparation and analysis of labneh

Lebneh is a fermented dairy product obtained by the filtration of yoghurt (Zabady) through cloth bags overnight. All types of milk were firstly processed into yoghurt (Zabady). Milks were separately heated to 82°C for 20minutes, then cooled to 45°C, 2% yoghurt starter culture were added to the warm milk, well stirred then incubated at 42±2°C up to complete coagulation. The resultant yoghurt kept at refrigerator 5±1°C for 24hours. 2% kitchen salt were added, the curd were transferred into the cloth bags and left for overnight filtration at room temperature to obtain homogeneous labneh. The amounts of labneh were weighed. The explained method of labneh was described by Tamime and Robenson.[42] Samples of labneh were taken to assess total solids (TS), fat, total nitrogen and ash according to AOAC,[25] while titratable acidity as described by Ling.[43] Total protein was calculated by multiplying total nitrogen×6.37. PH values were measured using a digital pH meter (Orian 680). Sensory evaluation of labneh was conducted according to Nelson and Trout,[44] where 45points were given for flavors, 30point for body and texture, 15points for appearance and 10points for acidity.

Blood biochemical constituents

Blood samples were collected at the end of the experimental period from all goats. Blood samples were obtained from the jugular vein of the goats in the morning before access to feed and water. Serum was obtained by centrifugation of blood and stored at–20°C until used for analysis. Commercial kits were used for all blood measures. Glucose concentration was determined by the method of Trinder[45] serum cholesterol by the colorimetric method of Stein[46] serum total protein (TP) by the Biuret method according to Henry et al.,[47] Albumin (A) concentration was determined according to Doumas et al.,[48] Kidney function was evaluated by measuring blood urea using the colorimetric methods of Henry and Todd.[49] Liver function was assessed by measuring the activities of aspartate aminotransferase (AST) and alanine amino transferase (ALT) by the method of Reitman and Frankel.[50] Hematological measures applied on all whole blood samples immediately after collection according to Schalm et al.[51] Enzymatic antioxidants activity in red blood cells was determined for glutathione peroxidase according to Moron et al.[52] Catalase was determined according to Caliborne.[53] Superoxide dismutase was determined according to Marklund and Marklund.[54]

Statistical analysis

Obtained data were subjected to statistical analysis using general linear models (GLM) procedure of SAS.[55] Significant differences among means were separated using LSD test according to Duncan[56] and significance was declared at $P<0.05$.

Results and discussion

Water quality

There was an improvement in water quality when exposed to the magnetic field with considerable change in the pH, total dissolved solids, total hardness, conductivity, salinity, dissolved oxygen, evaporating temperature, minerals, organic matter and total count of bacteria (Tables 2 & Table 3). The increase of salinity due to the magnetic exposure could be attributed to increasing soluble salts which concurred with the conductivity, while increasing dissolved oxygen could be due to the decrease in organic matter in magnetic water. Physics shows that water changes weight under the influence of magnetic fields. Increasing both the electric conductivity and the dielectric constant of water was documented.[57] Some researchers reported that magnetic treatment affect water properties such as light absorbance, pH, surface tension[58] and amount of oxygen dissolved in water.[59] Normal water has a pH level of about 7, whereas magnetic water can reach pH to 9.2 following the exposure to 7000 gauss strength magnet for a long period of time.[8] Ibrahim[57] concluded that, the applied magnetic field may affect the formation of hydrogen bonds of water molecule and that may lead to conformation changes. These changes may be the reason for the observed variations in both conductivity and dielectric content.

Table 2 Physiological properties of ordinary and magnetically treated water used in the experiment

Physical Properties	Unit	Treatments		
		Control	1200gauss	3600gauss
pH	-	6.76	7.39	7.44
Total Dissolved Solids (TDS)	mg/L	658	673	697
Total Hardness	mg/L	432	445	459
Conductivity (EC)	Ms/cm	696	731	749
Salinity	mg/L	370	385	395
Dissolved Oxygen	ppm	6.4	7.1	7.3
Evaporating Temperature	gm/hour	0.77	0.74	0.72

Table 3 Chemical analysis and total count of bacteria of ordinary and magnetically treated water used in the experiment

Parameters	Unit	Treatments		
		Control	1200 Gauss	3600 Gauss
Sodium (Na^+)	ppm	6.4	6.6	7.1
Potassium (K^+)	ppm	1.5	1.7	1.8
Ammonia (NH_4^+)	ppm	3.1	2.9	2.8
Calcium (Ca^{2+})	ppm	112.9	118.3	120.5
Magnesium (Mg^{2+})	ppm	112.7	114.7	117.3
Chloride (Cl^-)	ppm	2.9	3.1	3.3
Carbonate (Co_3^{2-})	ppm	3.9	4.1	4.3
Bicarbonate (HCo_3^-)	ppm	25.2	25.9	26.8
Organic Matter	ppm	55	49	41
Total Count of Bacteria	CFU	2.81	2.8	2.8

It was reported that water passed through the magnetic field acquires finer and more homogeneous structure.[60] This increasing fluidity, dissolving capacity of various constituents like minerals and vitamins[61] and consequently improving the biological activity of solutions positively affecting the performance of human being, animal and plants.[6] Hussen[62] reported that magnetic water lead to an increase of blood flow and supply of oxygen and nutrients to the cells. It is also; possible that exposure to electromagnetic field can ameliorate the deleterious effect of free radicals by decreasing the chemical reactions that caused damage to DNA, proteins and lipids. Alternatively, applied magnetic fields to water through using magnetic pipe may increase their rates of degradation by reaction with protective enzymes such as catalase and superoxide dismutase.[63]

Digestibility and nitrogen balance trials

Dry matter intake (DMI) was significantly increased ($P<0.05$) for bucks drink magnetic water supplied with 3600gauss (T_2), while the difference was insignificant ($P>0.05$) between those consumed ordinary tab water (C) and group supplied with 1200gauss (T_1) (Table 4). The highest values of digestibility coefficients were recorded with the two groups used magnetic water (T1 and T_2). These were reflected on TDN, DCP and N-utilization values. Qiu-jiang et al.[64] found that sheep consumed magnetic water significantly increased DM intake and the apparent digestibility of OM, CP, cellulose, semi-cellulose, Ca and P by 17.3%, 4.4%, and 5.0%, 4.8%, 3.8%, 0.6% and 2.8%, respectively. Also, levy et al.[65] reported that digestibility of dry matter tended to increase and metabolizable energy was converting more efficiently to gain with magnetic drinking water. However, Rodriguez et al.[66] showed positive impact of magnetic exposure on weight gain, feed utilization and reproductive traits of rabbit bucks. Moreover, Attia et al.[67] illustrated that bucks consumed magnetic water significantly increased feed intake, metabolic profiles and body weight.

In paradox to this elucidation, Patterson and Chestnutt[21] found that magnetic drinking water tended to have adverse effects on feed intake, nutrients utilization and lamb performance. Nitrogen retained was positive for all experiment groups, it was significantly ($P<0.05$) improved when bucks drinking magnetic water compared to control group. Results of nitrogen retained as a percentage of N-intake was obviously higher ($P<0.05$) with T_1 and T_2 than the control group. The same trend was observed for N-utilization when it expressed as N-retained/N-absorption (%). These results were in agreement with those found by Neto et al.,[68] who found that N retention by body weight were elevated with drinking treated water, probably resulting from decreased nitrogen excretion in urine.

Ruminal fermentation

Ruminal pH values significantly ($P<0.05$) decreases in the rumen at the two levels of magnetic (1200 and 3600gauss) in comparing with the control one (Table 5). Group consumed ordinary tap water was showed highest ($P<0.05$) NH_3-N value and lowest ($P<0.05$) TVFA's concentrations than those consumed magnetic water. The higher ($P<0.05$) obtained VFA's with the two magnetic groups could be reflected from their more digestibility coefficients, or the more utilization of dietary energy and positive fermentation in the rumen. The highest number ($P<0.01$) of total bacteria was recorded with T_2 followed by T_1, compared with C group. Microbial protein yield were significantly ($P<0.01$) increased for magnetic groups than control group. The reduction of ammonia nitrogen in the rumen liquor appears to be a result of increased incorporation of ammonia nitrogen into microbial protein and it was considered as a direct result to stimulated microbial activity. As the depletion of ammonia by rumen micro flora means increased microbial protein caused by drinking magnetic water, which leads to activation of cells activated

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by the metabolic processes.[69,70] Al-Hafez et al.[70] illustrated that sheep consumed magnetic water significantly decreases ruminal pH at the level of 1400gauss, with non significant differences in ammonia concentration between groups.

Table 4 Effects of magnetic water on dry matter intake (g/h/d), digestibility coefficients, nutritive values and nitrogen utilization of Zaraibi bucks (means±SE)

Items	Treatments				
	C	T_1	T_2	SEM	Sig.
DM intake (g/h/d)					
Total DMI, g	1076.78^b	1114.09^b	1169.43^a	13.98	*
Digestibility coefficients (%)					
DM	62.39^c	63.83^b	65.22^a	0.32	**
OM	65.35^c	66.66^b	67.92^a	0.29	**
CP	60.37^c	63.47^b	66.11^a	0.21	**
CF	56.47^c	58.76^b	61.19^a	0.57	**
EE	59.93^c	61.33^b	62.61^a	0.31	**
NFE	71.44^b	72.05^a	72.65^a	0.22	*
Nutritive values (%)					
TDN	62.22^c	63.46^b	64.67^a	0.28	**
DCP	6.58^c	6.82^b	6.96^a	0.03	**
Nitrogen utilization (g/h/d)					
N-intake (g/d)	18.79^b	19.16^b	19.70^a	0.14	*
N-absorbed (g/d)	11.34^c	12.16^b	13.02^a	0.09	*
N- retained (g/d)	4.98^b	5.82^a	6.30^a	0.09	*
N-balance as % of N-intake	26.50^b	30.38^a	31.98^a	0.34	*
N-balance as % of N- abso.	43.92^b	47.86^a	48.39^a	0.42	*

** P<0.01 and *P<0.05

a, b and c, means in the same row with different superscripts are significantly (P<0.05) different

C, Group supplied with ordinary tab water (control)

T_1, Group supplied with 1200 gauss; T_2, Group supplied with 3600gauss

Table 5 Effects of magnetic water on rumen parameters of Zaraibi does (means±SE)

Items	Treatments				
	C	T_1	T_2	SEM	Sig.
PH	6.65^a	6.39^b	6.31^b	0.06	*
NH_3-N concentration(mg/100mlR.L)	16.91^a	14.84^b	14.15^b	0.57	*
VFA's Concentration (meq/100 mlR.L)	9.66^b	12.08^a	12.83^a	0.62	*
Total Bacteria counts×10^7 cfu/ml	6.86^c	8.18^b	8.93^a	0.09	**
Microbial Protein Yield (mg/dl)	149.60^c	161.80^b	173.20^a	1.28	**

**P< 0.01 and *P< 0.05

a, b and c, means in the same row with different superscripts are significantly (P<0.05) different

Methane production

Methane was decreased in a linear manner with consuming magnetic water by about 30.14 and 32.19% for 1200 and 3600gauss, respectively relative to the control (Table 6). Kessel and Russell[71] reported that it were able to elegantly demonstrate the relationship between feed composition, rumen acidity, and methanogen activity.

Degradation kinetics

It illustrated that washing loss fraction “a” of DM, NDF and CP among groups was insignificantly different (P>0.05) (Table 7). Degradable fraction “b”, rate of degradation “c” and effective degradability “ED” of DM and NDF for the control group were less compared with other groups; these could be related to the its less nutrients digestibility. Higher (P<0.01) degradable fraction "b" of DM and NDF and higher effective degradability "ED" of NDF were noticed with group consumed magnetic water with 3600gauss. However, insignificantly different (P>0.05) found between the two magnetic groups for their rate of degradation "c" and effective degradability "ED" of DM. It seems that magnetic water had no effect on any of degradation kinetics and the effective degradability for crude protein. Kattnig et al.[72] cited that changes in species of ruminal bacteria between sheep drinking water a high salts compared with those drinking low salts water. This change leads to variation in nutrients degradability in the rumen.[73] Al-Hafez et al.[70] illustrated that sheep consumed magnetic water had significantly increased in the bacteria and protozoa counts at 700 and 1400gauss levels compared with the control one. If such changes in microbial populations occurred, they had discernible effect on the rate of DMD.

Table 6 Effects of magnetic water on methane production (ml/gDM) *in vitro* for 24h incubation

Items	Treatments				
	C	T_1	T_2	SEM	Sig.
CH_4(ml/gDM)	14.60_a	10.20_b	9.90_b	0.19	*
CH_4 depression, %	-	30.14	32.19	-	-

*P<0.05
a and b, means in the same row with different superscripts are significantly (P<0.05) different

Table 7 Effects of magnetic water on the degradation kinetics of DM, NDF and CP for ration (mean±SE)

Items	Treatments				
	C	T_1	T_2	SEM	Sig.
DM					
a	25.32	25.12	25.39	0.12	NS
b	44.24^c	46.93^b	48.87^a	0.11	**
c	0.044^b	0.048^a	0.049^a	0.001	*
ED DM	46.03^b	48.11^a	49.58^a	0.5	**
NDF					
a	8.97	9.08	9.11	0.04	NS
b	53.26^c	55.96^b	57.77^a	0.33	**
c	0.031^b	0.036^a	0.039^a	0.001	*
ED NDF	29.35^c	32.51^b	34.42^a	0.45	**
CP					
a	23.46	23.47	23.44	0.03	NS
b	51.73	52.03	52.09	0.13	NS
c	0.062	0.062	0.063	0.002	NS
ED CP	52.09	52.27	52.48	0.25	NS

**P<0.01, *P<0.05 and NS, Not significant
a, b and c, means in the same row with different superscripts are significantly (P<0.05) different
a, soluble fraction (%); b, potentially degradable fraction (%); c, rate of nutrient degradation (% h^{-1})
ED, Effective Degradability=a+[bc/c+k], where k is the out flow rate

Feeding experiment of lactating goats

Daily feed intake and water consumption: Averages of daily dry matter intake by Zaraibi goats during the experimental periods are summarized in Table 8. Higher feed intake was recorded for T_2, while insignificantly different (P> 0.05) between the control and T_1 (Table 8). The same trend was noticed with bucks in the digestibility trial. The R/C ratio recorded 59/41 for C and T_1 and 60/40 for T_2. Does consumed the least amount for water with control group (228.09ml/kgw$^{0.75}$), while recorded the highest consumption with T_2(259.71ml/kgw$^{0.75}$). When the daily water consumption was related to DM intake (ml/g DM intake) it kept the same trend above where it ranged from 2.61 (C) to 2.75 (T_2). The result indicates a direct relationship between voluntary water consumed and milk yield in dairy goats, these finding are in accordance with those obtained by Ibrahim et al.[74] Al-Mufarrej et al.[6] attributed the save in water intake and the high benefit of the consumed magnetic water to the changes in water properties such as surface tension, fluidity, absorbency, pH level and dissolving capabilities. In paradox to this elucidation, Lardy and Stolltenow[75] emphasized that water magnetization affects some of the minerals utilization such as calcium and magnesium which in turn may converts water to be unpalatable.

Milk yield and composition: Daily milk yield of Zaraibi does consumed magnetic water was significantly higher (p<0.01) than control group (Table 9). Those in T_2 had more milk yield then T_1 and the control one. It also had yielded significantly more 4% FCM, milk fat and protein than other groups. The increase in milk production may be attributed to the outcome of the positive impact of magnetic water on digestion; absorption; growth of cells and their functions; circulatory system and udder.[62,76] This could be also, due to that magnetic water works on increasing in the secretion of the prolactin hormone through the effect of the endorphins hormone, which increases the stimulation and thus lead to an increase in milk production.[77] The findings are consistent with Al-Maro[78] who noted a significant increase in milk production with ewes drink intensity magnetic water (700 and1400gauss) in comparison with the control. As well these results were consistent with the finding of Shamsaldain and Al Rawee,[18] who have suggested that milk production from Awassi sheep was increased when they drink magnetic water intensity (1000gauss) compared to tap water. Improvement in milk yield was associated with an increase in fat and protein production, which agreed with that reported by Al-Jack,[79] Sargolzehi et al.,[4] Shamsaldain and Al Rawee.[18]

Zaraibi does drinking magnetic water had significantly higher (p<0.05) TS, SNF, fat, protein and lactose(%) than control group, while ash content was not affected. Lower milk composition(%) and yields(g/d) were found for does drinking ordinary tap water. Reason for the high percentage of milk protein with magnetic water may be due to the amount of milk protein is directly proportional to the amount of milk produced, or to an improvement in increasing the digestion of crude protein, where drinking magnetic water works to an increase in small intestines movement for sheep and increase the processes of digestion and absorption.[80] Rodriguez et al.,[81] noted that magnetic field could leads to a decrease in the melatonin hormone in lactating cows, Suttie et al.,[82] cited decrease the melatonin hormone who leads to an increase in the (IGF-1) Insulin-like growth factor-1 or may lead to an increase in the secretion of prolactin hormone and this increase are important in the secretion of milk. These results agreed with Al-Maro[83] whereas in his study on Awassi sheep milk fat increased as well as protein, lactose and SNF.

Table 8 Effects of magnetic water on dry matter intake and water consumption of lactating Zaraibi does (means±SE)

Items	Treatments				
	C	T_1	T_2	SEM	Sig.
Number of doe	5	5	5	-	-
Body weight, kg	36.47	36.39	35.9	-	-
Metabolic body size, W0.75	14.84	14.82	14.67	-	-
DM Intake, g/d					
CFM	536.39^b	540.90^b	549.92^a	4.19	*
Corn silage	380.32^b	388.63^b	417.08^a	2.23	*
Rice straw	380.73^b	385.26^b	416.99^a	2.12	*
TDMI	1297.44^b	1314.79^b	1383.99^a	7.74	*
R:C ratio	59:41:00	59:41:00	40:60	-	-
DM g/kgw$^{0.75}$	87.43^b	88.72^b	94.34^a	2.57	*
Water consumption, ml					
ml/d	3385^b	3520^{ab}	3810^a	55.97	*
ml/kgw$^{0.75}$	228.09^b	237.52^{ab}	259.71^a	1.96	*
ml/g DM intake	2.61^b	2.68^{ab}	2.75^a	0.03	*

*P<0.05

a and b, means in the same row with different superscripts are significantly (P<0.05) different

Table 9 Effects of magnetic water on milk yields and milk composition for lactating Zaraibi does (means±SE)

Items	Treatments				
	C	T_1	T_2	SEM	Sig.
Production (kg/day)					
Milk yields	0.902^c	1.011^b	1.049^a	0.03	**
4% FCM	0.796^c	0.974^b	1.035^a	0.19	**
Milk fat	0.029^b	0.038^{ab}	0.041^a	0.04	*
Milk protein	0.027^b	0.032^{ab}	0.034^a	0.02	*
Milk composition (%)					
Total solids	11.51^b	12.66^a	12.88^a	0.19	*
Solids not fat	8.32^b	8.88^a	8.94^a	0.13	*
Fat	3.19^c	3.78^b	3.94^a	0.04	*
Protein	3.03^b	3.19^a	3.23^a	0.05	*
Lactose	4.56^b	4.97^a	4.98^a	0.03	*
Ash	0. 73	0.72	0.73	0.01	NS

**P<0.01, *P<0.05 and NS, Not significant

a, b and c, means in the same row with different superscripts are significantly (P<0.05) different

Labneh manufacturing

Yoghurt from T_1 and T_2 groups drink magnetic water was coagulated in shorter time (176 and 173minutes, respectively), compared with control group (184minutes) (Table 10). The shorter time may be due to the higher total solids of milk with groups drink magnetic water. The higher acidity and lower pH with magnetic groups emphasize the activity of starter culture in inverting lactose into lactic acid.[84] So, it can say no inhibition effect of milk obtained from goats offered water exposed to magnetic system.

Yield and chemical composition of labneh

It is clear that yield of labneh from milk got from goats in T_1 and T_2 groups are higher than that obtained from control group (Table 11). The higher total solids of milk led to higher yields. T.S, fat, protein and ash of control labneh were lower than that produced from magnetic groups. It is known that most of milk component retained into the curd and the whey protein, some of lactose and minerals are strained into the whey. So the higher T.S, fat, protein and minerals of labneh of magnetic groups owed to their higher content in milk.

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These observations are similar to those reported by Mehana et al.[85] and Ibrahim et al.[74]

Table 10 Effects of magnetic water on the recoagulation time of yogurt making

Items	Treatments		
	C	T_1	T_2
Acidity,%	0.71	0.76	0.79
pH	4.72	4.61	4.57
Coagulation time, minutes	184	176	173

Table 11 Effects of magnetic water on yield and gross chemical composition of labneh

Items	Treatments				
	C	T_1	T_2	SEM	Sig.
Labneh yield					
Yield,%	23.81^b	25.12^a	25.86^a	1.08	*
Chemical csomposition					
Total Solids,%	43.29^b	45.28^a	45.74^a	1.42	*
Fat,%	18.71^b	20.60^a	20.87^a	0.93	*
Fat/DM,%	43.22^b	45.49^a	45.63^a	1.04	*
Protein,%	14.05^b	15.20^a	15.38^a	0.72	*
Protein /DM,%	32.45^b	33.57^a	33.62^a	0.88	*
Ash,%	3.9	3.95	3.98	0.65	NS

*P<0.05 and NS, Not significant

a and b, means in the same row with different superscripts are significantly (P<0.05) different

Organoleptic properties

An important parameter to determine the quality and shelf life of labneh is sensoric properties (Table 12). For all treatments as the storage time progressed the total scoring points decreased. It seems that type of milk had no marked effect on color and appearance of labneh since color of goats' milk is bright white and not affected by type of drinking water. Labneh with T_2 gained higher total scoring points. The higher fat content gives labneh smooth texture and rich flavors, which admired the judgers. The clean acid flavor was more pronounced in labneh of treated groups than control one, but after storage with increasing the acidity development, the sharp acidity flavor annoyed the panelists.[86] Fresh labneh with C, T_1 and T_2 gained total scoring points 94, 96 and 98 out of 100, respectively.

Blood hematological and biochemical constituents

Hematological parameters data (Table 13) revealed significant differences (P<0.01) among groups in concentrations of hemoglobin (Hgb), red blood cells (RBC's), and white blood cells (WBC's). The highest values were recorded with group received magnetic water at the level of 3600 gauss, while the lowest were recorded with does in control group. The improvement in metabolic profiles of does that drank magnetic exposed water could be attributed to enhancing metabolic cycles, minerals solubility such as Fe and/or Cu as evidenced by increasing RBC's and Hgb and nutrients transfer to various body cells, movement of blood within the arteries facilitating the transport of oxygen-bearing blood and nutrients to different body cells.[87] Increasing the RBC's count has attributed to increase the intensity of water processor magnetically to that the magnetic field works on iron attract in the blood and then connect the blood in larger quantities to the area causing an increase the number of RBC's and Hgb and therefore carried oxygen more to cells.[88] Also, the increase in the WBC's count may be due to increase the severity of the water processor magnetically to increase the emergence of these cells configured sites in the bone marrow into the circulatory system by the impact of some hormonal factors.[89] Also, it has led to that an increase in body immunity through the increased proportion of lymph cells. Rise of lymph cells percent may be due that magnetic water increases the content of immune globulin in the blood and increase the number of defensive white blood cells.[90]

Table 12 Evaluation scoring points of labneh through 21days at 5±1°C

Items		Treatments		
		C	T_1	T_2
Fresh	F	43	44	45
	BT	29	29	30
	AC	13	13	13
	A	9	10	10
	T	94	96	98
7days	F	41	43	43
	BT	27	28	30
	AC	13	13	13
	A	8	9	9
	T	89	93	95
15days	F	36	38	38
	BT	25	26	28
	AC	11	11	11
	A	7	8	8
	T	79	83	85
21days	F	30	32	33
	BT	22	24	25
	AC	8	8	8
	A	6	7	7
	T	66	71	73

F, flavour (45points); BT, body & texture (30points); AC, appearance & color (15points); A, acidity (10points); T, total score point (100 points)

It was found that using magnetic water at the levels of 1200 and 3600gauss caused a significant (P<0.05) increase in glucose, total protein, albumin and globulin compared with does that drank unmagnetic water. On the other hand, significantly (P<0.05) decreased in cholesterol concentration with treatments groups than control group. Furthermore, water treatments did not influence albumin/globulin ratio. This finding agrees with those reported by Shamsaldain and Al Rawee[18] and Attia et al.[3] Increasing the concentration of total protein level may play positive role in an increase in growth and the consumption of protein to build somatic cells.[91] Luo et al.[92] reported that single exposure to electromagnetic field (EMF) decrease the serum values of total cholesterol concentration and triglyceride level. The mechanism of EMF action in biological systems can be examined by its interaction with moving charges and enzymes activities rates in cell-free systems increasing transcript levels for specific genes. However, EMF also interacts directly with electrons in DNA to affect protein biosynthesis.[93] Effect of drinking treated water on the kidney function parameters, showed that treatments at the levels of 1200 and 3600gauss caused a significant (P<0.05) decreased in urea than control one. Data of AST and ALT showed that magnetic water had a significant (P<0.05) decrease in AST and ALT than unmagnetic water. So, these parameters showing improved renal and liver function due to magnetic treatment.

Blood antioxidant enzymes

Magnetic water resulted in higher (P<0.05) glutathione peroxidase (GSH-Px), catalase (CAT) and superoxide dismutase (SOD) compared to those of goats that drank unmagnetic water (Table 14). Catalase enzyme activity was highly remarkable with T_2 comparison to other groups. Poor water quality negatively affected animal performance and welfare.[3,94] Conti et al.[95] illustrated that the increase in antioxidant status in blood plasma suggested increasing stability of cell. Antioxidants are reducing agents, and limit oxidative damage to biological structures by passive free radicals.[96] It's well known that antioxidant enzymes mainly SOD and CAT is the first line defensive against free radicals which cause oxidative damage in animal tissues. Catalase (CAT) is one of the most important intracellular enzymes in the detoxification of the oxidant hydrogen peroxide. Meantime, the activity of AT and SOD enzymes is inhibited with high level of toxic metabolites.[97] Glutathione peroxidase (GSH-Px) is the most powerful antioxidant enzyme protects cellular proteins against reactive oxygen species (ROS) in the body.[98,99]

Table 13 Effects of magnetic water on hematological profiles and blood biochemical constituents of Zaraibi does (means±SE)

Items	Treatments				
	C	T_1	T_2	SEM	Sig.
Hemoglobin(Hgb), g/dl	9.59^c	10.11^b	10.63^a	0.06	**
Red blood cells (RBC's)×106/µl	11.21^c	11.84^b	12.29^a	0.08	**
White blood cells (WBC's)×103/µl	7.23^c	8.30^b	8.98^a	0.23	**
Glucose, mg/dl	64.13^c	70.26^b	76.93^a	1.06	**
Cholesterol, mg/dl	86.18^a	74.22^b	71.82^b	2.3	*
Total Protein, g/dl	7.21^c	7.88^b	8.53^a	0.12	**
Albumin, g/dl	3.88^c	4.15^b	4.46^a	0.07	**
Globulin, g/dl	3.33^b	3.73^{ab}	4.07^a	0.06	*
A/G ratio	1.165	1.116	1.09	0.03	NS
Urea-N, mg/dl	15.33^a	11.81^b	11.14^b	0.59	*
AST,u/L	38.93^a	31.74^b	30.17^b	1.13	*
ALT,u/L	15.25^a	11.52^b	11.23^b	0.41	*

**P<0.01, *P<0.05 and N.S, Not significant

a, b and c, means in the same row with different superscripts are significantly (P<0.05) different

Table 14 Effects of magnetic water on of antioxidant enzymes of Zaraibi does (means±SE)

Items	Treatments				
	C	T_1	T_2	SEM	Sig.
GSH-Px, u/gHb	260.73^b	284.76^a	292.84^a	4.08	*
CAT, u/gHb	1516.32^c	1695.16^b	1876.83^a	11.98	*
SOD, u/gHb	853.75^b	929.62^a	946.11^a	9.62	*

*P<0.05

a, b and c: means in the same row with different superscripts are significantly (P<0.05) different

Conclusion

Whereas magnetic treatment resulted in improved water quality which consequently improves nutrient digestibility, saves water consumption, optimizing rumen fermentation parameters, and it could an effective way to reduce methane production and contributing to mitigate environmental impact in livestock, positive animal health, which is reflected in the increase in milk yield and its component and it is possible to process high quality labneh and improves blood picture and antioxidant status. A reappraisal of magnetizing treatment of water containing differ powerful magnetic field and longer time on various aspects of goats production is suggested for future studies.

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Conflict of interest

Author declares that there is no conflict of interest.

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