The Journal of Animal & Plant Sciences, 31(1): 2021, Page: 317-321
ISSN (print): 1018-7081; ISSN (online): 2309-8694

Short Communication

PHYSICOCHEMICAL PROPERTIES OF MAGNETIC WATER AND ITS EFFECT ON EGG PRODUCTION TRAITS IN HENS AT LATE LAYING PERIOD

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ABSTRACT

This study was conducted to evaluate the egg production traits of laying hens receiving magnetic water (MW) for one month. Sixty Fayoumi hens at 54 weeks of age were used. On d 1 of the trial, hens were randomly assigned to control (non-magnetic water) and treatment (magnetic water, MW) groups. During the experiment, pH and electrical conductivity (EC) of water were recorded. The water nano-structure was investigated by electron microscopy. In parallel, egg mass, egg number, egg weight, egg production, and feed intake were recorded daily. Results showed that both pH and EC values of MW were higher compared to those of non-magnetic water ($P \leq 0.05$). In MW, notable changes in the order and size of water molecules at the edge of water clusters were observed. Providing MW for the first two weeks did not affect any of productive traits. From third week of the experiment, egg production of MW group (34.5 ± 1.8 %) was significantly higher than this (27.8 ± 2.1 %) of control ones. In conclusion, physiochemical properties of MW may indirectly maintain hens' productivity in late age. Nevertheless, interdisciplinary investigations should be carried out to elucidate the mode of action of MW and probable side effects if any.

Keywords: magnetized water; magnetic field; egg production; egg weight; water properties.

https://doi.org/10.36899/JAPS.2021.1.0219 *Published online August 26, 2020*

INTRODUCTION

Water magnetization, as a clean and zero energy consumption application, has recently received a great interest in different fields. However, magnetic water (MW) is still a point of contention in different scientific societies. Magnetic water expression refers to magnetic field treated water that gains new properties. Alabi *et al*. (2015); El Sabry *et al*. (2018); Wang *et al*. (2018) stated that exposing water to a magnetic field induces several direct or indirect changes in electromagnetic, physical and chemical properties of water such as: pH, electrical conductivity, surface tension, viscosity, boiling point, and molecular energy. Alabi *et al*. (2015) and Esmaeilnezhad *et al*. (2017) mentioned that there are number of theories to explain: what is magnetization, and how the magnetic field affects physiochemical properties of water.

Attributed to the new properties of MW, water magnetization application was suggested as an efficient eco-friendly solution for some industrial problems e.g. protecting the pipelines from corrosion, as an efficient scaling inhibitor and enhancing the efficacy of cooling systems (Esmaeilnezhad *et al*., 2017; Al Helal *et al*., 2018; Wang *et al*., 2018). In the biomedical field, provision of MW to rats for 30 days increased mineral density and mineral content of their bone compared to those of rats receiving non-magnetic water (Balieiro-Neto *et al*., 2017). In addition, providing MW to diabetic rats protected their kidneys from nephrotoxic damages as one of type 2 diabetes related complications (Zayed *et al*., 2018).

In animal production systems, using MW application is a point of contention because of the limited number of studies and their mixed results. For instance, Alhassani and Amin (2012) showed that broiler of the MW group (1 Tesla, 15 min.) had superior results for feed conversion ratio and production index compared to the non-magnetic water group. In addition, the provision of the MW for laying hens improved the internal quality of eggs as well as the eggshell breaking strength (El-Sabrout and Hanfy, 2017; El Sabry *et al*., 2018). El-Hanoun *et al*. (2017) found that the MW improved the productive performance of geese. On the other hand, Al-Mufarrej *et al*. (2005) mentioned that providing MW to broiler chicks has no effect on their performance. These mixed results may be attributed to several factors such as the strength of magnetic field, duration of exposing water to magnetic field or the period of the study.

As the hen ages, egg production traits such as laying rate and egg quality decrese (Zita *et al*., 2012). Due to the potentiality of MW application, we hypothesized that providing MW to older laying hens may maintain or improve their productivity. Therefore, this study was conducted to evaluate the effect of magnetic field on water properties and subsequent effects on egg production percentage, egg weight, and feed intake of Fayoumi laying hens at the late laying period.

MATERIALS AND METHODS

Experimental animals*:* This study was approved by the Institutional Animal Care and Use Committee of Cairo University Protocol No. (CU-II-F-37-17). To avoid handling effect on hens, two weeks prior the start of the experiment, sixty Fayoumi hens were randomly assigned to control (non-magnetic water) and treatment (magnetic water, MW) groups, 30 hens per group. Hens were placed in individual cages in an open sided house (average of ambient temperature ranged from 24 - 26 °C). At 54 weeks of age, on day 1 of the experiment, 3000 Gauss magnetic conditioner apparatus was attached only to the exterior surface of water pipeline of MW treated group. The experiment lasted for one month. All hens were provided with water and feed *ad libitum*. Laying hens were fed a diet containing 16% crude protein, 2700 kcal/kg of metabolizable energy, 3.5% calcium, 0.42% available phosphorus.

Water measurements: Five water samples from each treatment were collected at days 1, 15 and 30 of experiment to measure pH using pH meter (805 MP, FISHER, Germany) and electric conductivity (EC) using a conductivity meter (WTW LF315 Conductivity Meter, USA). At the end of the experiment (day 30), water samples were collected and negatively stained. Then, water were loaded on carbon–coated grids and air-dried to be ready for investigation by electron microscope (JEOL JEM-1400, USA). It was assumed that the pattern of distribution of dye precipitation and stained salts may demonstrate the physical changes in water molecules.

Egg production traits: Daily egg production and egg weight for each hen were recorded throughout the experimental period. Then, egg mass, average egg weight and egg production percentage during the 1st half of the experiment (d1-15), the second half of the experiment (d16-d30) and overall experimental period (d1-d30) were calculated as follow:

Egg mass (g) (d1-15), (d16-30), (d1-30) = Σ eggs' weight.

Average egg weight (g) (d1-15), (d16-30), (d1-30) = total eggs' weight / number of eggs.

Egg production (%) (d1-15), (d16-30), (d1-30) = Egg number/period*100.

Daily feed intake = Total feed intake all over experimental period/30days

Statistical analysis: The data on water pH and EC were were collected and analysed using JMP pro 5 statistical software (2005). The egg production data were analyzed from day 1-15, day 16-30 and day 1-30. The t-test was applied to compare between the properties of MW and non-magnetic water. It was also used to compare the productive parameters of hens receiving MW or non-magnetic water.

RESULTS AND DISCUSSION

Changes in water properties: The MW application is eco-friendly, zero energy consumption and costless when a permanent magnet is used. Magnetized water can be made by passing water through a magnetic field. Results showed that the pH of MW (7.03 ± 0.00) was higher than the pH of non-magnetic water (6.76 ± 0.07) during the experimental period ($P \leq 0.05$). Also, the EC of the MW (422.14 ± 1.46) was higher ($P \leq 0.05$) than those of non-magnetic water (394.28 ± 1.97). These changes in water pH and EC were determined to ensure that the hens were contentiously receiving magnetic water throughout the experimental period. Also, Yacout *et al*. (2015) recorded similar pH and EC values during his study on goats.

Kotb (2013) suggested that the atoms' nuclei in the water are polarized under the magnetic field and then those atoms act as tiny magnets. Moreover, he suggested that the increase in pH value is due to the polarization and the uniform order of atoms. However, Gaafar *et al*. (2015) observed that an increase in EC of tap water under magnetic field (3000 - 5000 Gauss) at variable exposure times ($t \leq 10$ min). The alteration in the water EC may be due to:1) the changes in the ions' charge and velocity of H+ ions or 2) the dipole moments of free molecules and clusters, including H-bond chains of the water under the effect of magnetic fields (Pang and Shen, 2013). They added that these chemical changes also may result in alterations in the physical structure of water.

The microscopic images showed that the magnetic field affected the nanostructure of MW (Figure 1)., It is clear that the molecules of the MW cluster were well ordered as opposed to the molecules of non-magnetic water, which were not well-ordered. Also, the MW molecules were smaller than those of non-magnetic water, specialy, at the edges of water clusters.. The change in the physical structure of water under magnetic field application has been reported and different theories gave different explanations. For instance, Chang and Weng (2006) suggested that the better order of the water molecules and bigger size of water clusters under applied magnetic field might be due to the increase in the number of hydrogen bonds. The micrographs of the dye precipitations showed the pattern of the effect of the magnetic field on the water (Figure 1). From both literature and the current study, there is a clear relation between chemical and physical properties of the MW.

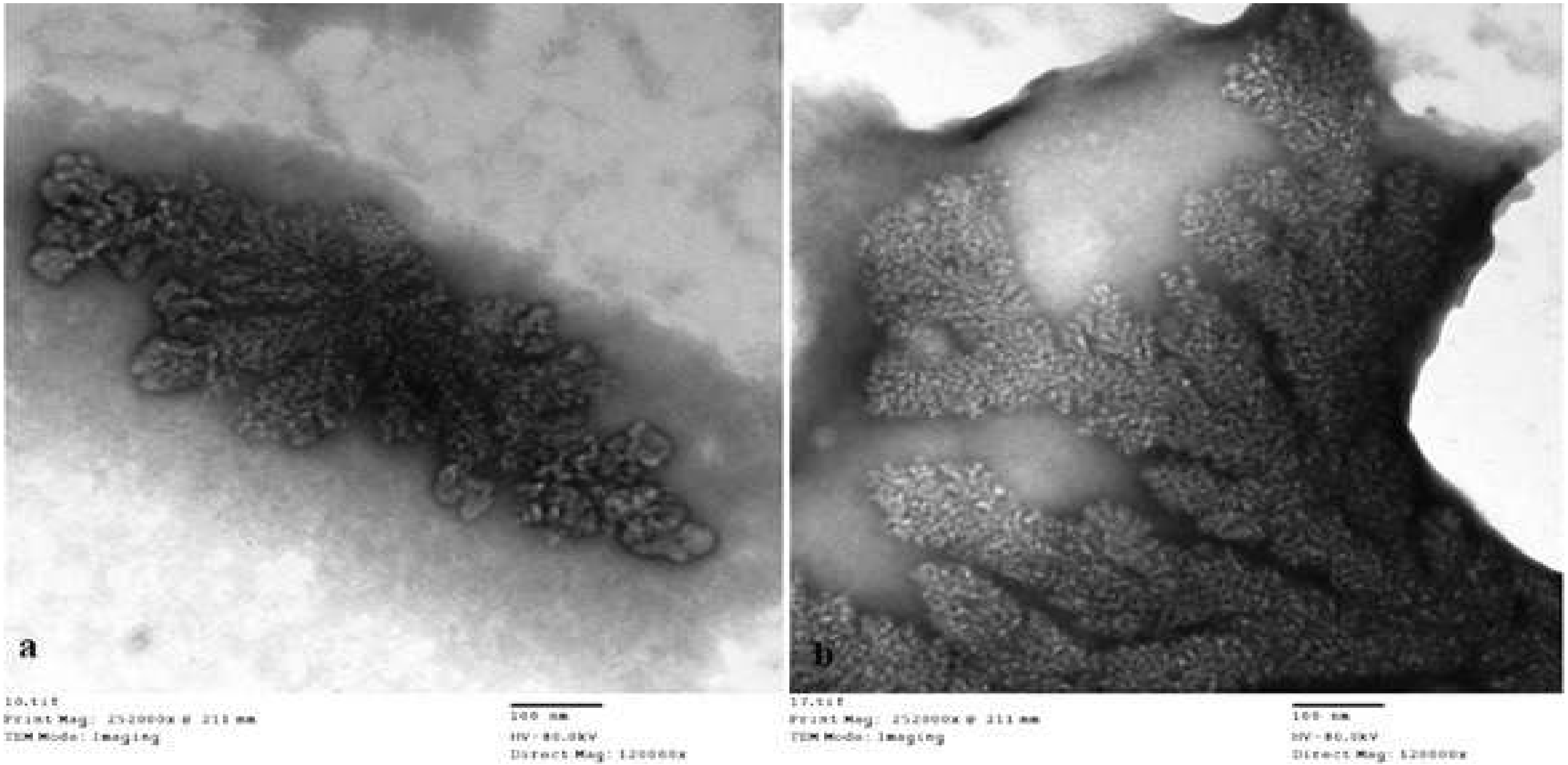

Figure 1. a) molecules of non-magnetic were not well ordered and big in size at the edge of water clusters (b) molecules of magnetic water were well ordered and small in size (electron microscope, 120000X).

Table 1. Effect of magnetic water (MW) and non-magnetic water (control) on egg production traits (±SE) in Fayoumi hens at late laying period.

Trait	Egg number			Egg mass (g)			Egg weight (g)			Egg production (%)		
Days	MW	Control	*p*-value	MW	Control	*p*-value	MW	Control	*p*-value	MW	Control	*p*-value
1-15	4.5 ±0.2	4.4±0.3	0.94	208.6 ±14.2	201.5±15.2	0.73	45.9±0.6	44.8±0.6	0.24	30.1 ± 1.9	29.8 ± 2.1	0.93
16-30	5.5±0.4[a]	4.1±0.4[b]	0.03	270.7±21.0[a]	191.9±22.8[b]	0.01	48.7±0.7[a]	44.8±0.7[b]	0.00	34.5± 1.8[a]	27.8 ± 2.1[b]	0.04
1-30	10.0±0.5	8.5±0.5	0.07	479.3±27.4[a]	392.5± 28.7[b]	0.03	47.5±0.6[a]	45.5±0.6[b]	0.04	32.3±1.8	28.5±1.9	0.07

Means ±SE within row of the same trait with different superscript differ significantly ($p \leq 0.05$).

Egg production traits: Fayoumi breed is a native Egyptian one that is able to survive under harsh nutritional and environmental conditions (El Sabry *et al*., 2012). Schilling *et al*. (2019) stated that Fayoumi breed is less vulnerable to numerous poultry diseases including Newcastle disease, when comparision with other breeds. However, Fayoumi breed has relatively lower egg production compared with other commercial breeds. For instance, the peak of egg production %, at 30 - 40 weeks of age, ranges between (49.5 - 56 %). The total egg production (hen per year) is around 130 eggs under rural condition or around 141 eggs under intensive condition (Sazzad, 1992; Khan *et al*., 2006). It is therefore timely to investigate the efficacy of using MW to improve the performance of the Fayoumi hens.

Mgnetic water presents one of the recent trends to enhance livestock production. In the current study, from day 1-15 of the experiment, egg number, egg mass, average egg weight and egg production % of both treatments were similar (Table 1). However, from 16-30 days, the egg number, egg mass, average egg weight and egg production % of the hens of MW group were significantly higher as compared to the hens of non-magnetic water group. Balieiro-Neto *et al*. (2017), also reported that providing MW to growing rats for 15 days did not improve the bone mineral density and bone mineral content, but providing MW for 30 days to rats resulted in a significant increase in the bone mineral density and bone mineral content. Taken together, perhaps providing MW for a longer period could positively affect hens' performance.

The overall results through the experimental period (1-30 days) showed that laying receiving MW exhibited superior results for egg weight and mass compared to those of hens receiving non-magnetic drinking water (Table 1), which indicates to accumulation effects of MW treatment on the productivity. Moreover, daily feed intake (120.6 ± 0.9 g) of hens of MW group was greater than feed intake (116.2± 0.8) of hens of control group (P= 0.0008). This greater feed consumption can be associated with the increase in the productivity of laying hens provided with MW.

Unfortunately, the available data on the effect of MW on the performance of laying hens are scant. El-Sabrout and Hanfy (2017) and El Sabry *et al*. (2018) found that the MW significantly improved internal egg quality and eggshell quality without any effect on layers productivity or egg weight. This inconsistency between the results ofprevious studies and present onse can be attributed to the genetic composition of breeds, age of flocks as well as the variation in experimental conditions. Generally, it appears that the change in MW properties have beneficial effects on the egg production.

Magnetic water has been shown to alter the pH of water to neutral or alkaline, which can mitigate the effects of oxidative stress. For example, Zayed *et al*. (2018) found that providing MW to type 2 diabetic rats can reduce oxidative stress, hyperlipidemia, uremia, and renal dysfunction. In human, Weidman *et al*. (2016) reported a relation between oxidative stress and blood viscosity. They reported a significant difference in whole blood viscosity when assessing an alkaline water versus a standard purified water during the recovery phase after exercise-induced dehydration. Therefore, it is plausible to suggest that the increase in pH value of MW can be a tool to modulate the stress physiology of laying hens and subsequently enhance performance.

Conclusion: From the data of the current study, it can be concluded that alteration in MW properties could indirectly influence the egg production traits. However, it appears that the effect of magnetic water on performance depends on the duration of provision of the MW treatment.

Acknowledgements: The authors extend thanks to their respected institutes and universities.

Conflict of interest: The authors declare no conflict of interest.

Animal welfare statement: Animal care and maintenance were performed in accordance with guidelines of Egyptian Research Ethics Committee. This study was approved by the Institutional Animal Care and Use Committee of Cairo University Protocol No. (CU-II-F-37-17).

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