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Impact of Short Term Exposure of Japanese Quail Eggs to Magnetic Field on Eggshell Thickness, Hatchability and Body Weight at hatch

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Abstract

Two experiments with a total of 1260 Japanese Quail eggs were conducted to study the impact of short term exposure to magnetic field (MF) on eggshell thickness, hatchability and body weight at one-day of age (BW). In the first experiment, a pilot study to identify the best treatments to be tested in the second experiment, 360 eggs in 2 ways-ANOVA with interaction design were divided randomly into 15 equal groups (3 replicates of 8 eggs per each group). Eggs were exposed to 3 intensities of MF (0, 750 and 1500Gauss)and 5 durations of exposure (5, 10, 15, 20 and 25 min) before incubation. Results indicated that, no significant effects of interaction between MF dose and duration of exposure was observed for eggshell thickness and BW at hatch. The highest hatchability rate was noted for treatment of 750 Gauss/20 min followed by 1500 Gauss/10 min ones. In addition, a linear effect was detected for BW in inconsiderable response to MF intensities (750Gauss) . In the second experiment, one-way ANOVA was performed using 900 eggs. Eggs were divided randomly into 3 equal treatments (0, 750 Gauss/20 min and 1500 Gauss/10 min) with 10replicates per each treatment (30 eggs per replicate). Results confirmed that both treatments (750Gauss/20 min and 1500 Gauss/10 min) had the same positive impact on hatchability and BW at hatch in compared with control ones. It might be concluded from this study that MF had no effect on eggshell thickness. However, it had positive impacts on hatchability and BW at hatch of Japanese quail. Therefore, it is recommended for breeders to implement in their hatcheries the most effective and efficient treatment, which is either 750 Gauss/20 min or 1500 Gauss/10min.

Keywords: Japanese Quail Eggs, Magnetic Field, Eggshell Thickness, Hatchability and BW at Hatch

1. Introduction

It has been reported that the magnetic technology was investigated within the plant fields, water, etc[1,2,3,4,5,6,8],but little attention was given to animal reproductive and production application[7], Several researches had studied the effect of electromagnetic field (EMF) and magnetic field (MF) on biological[9,10], productive [11], and reproductive[12,13,14] aspects of birds.

Also, **Keirs *et al.*, (2005) [15]**reported that application of electromagnetic field modification unit son egg laying hens in commercial flocks improves production parameters, which has the physiological indices to improve the productive performance[**17**]. They expect that technique will be the future ones for these purposes. In the same context, **Ibrahim *et al.***[**18]** reported that using low-

important welfare implications as well as gross economic advantage. In the same context, **Shafey *et al.*[16]**found that short term exposure of layer-type breeder eggs to MF of 750 Gauss (0.075 mT) at 50 Hz, for 40 and60 min increased egg weight loss during incubation and chick weight at hatch day. Recently, some attention in scientific research has been paid to implement the application of exposing the hatching eggs to the MF as friendly and nature technique on living organisms from the aspect of enhancing

intensity magnetic flux (110 Gauss) increased hatchability, body weight (BW) at 1 and 4weeks of age, and feed conversion ratio in quails. Moreover, the hatchability of broiler-breeders' eggs was

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increased in response to MF exposure before **[17]**or during hatching**(19)**. The MF mode of action might be attributed, at least in part, to the improvement of the physical characteristics of eggs' water almost by 65 to 70[**20,21**]. Also, **Golovleva *et al.* [22]** stated that the MF inflicted the properties of the polar liquid**..**

Moreover, the hatchability of broiler-breeders' eggs was increased in response to MF exposure before **[17]** or during hatching**[19]**. The MF mode of action might be attributed, at least in part, to the improvement of the physical characteristics of eggs' water by 65 to 70% [**20,21**]. Also, **Golovleva *et al.*[22]**stated that the MF inflicted the properties of the polar liquid. Moreover, it is well known that the impact of environmental conditions on hatching indices of poultry eggs is sufficiently important that new methods for their improvement are sought, among others through exposing the eggs during hatching to an artificially generated MF of variable frequency**[23,24].**There is lack of information regarding the impact of MF dose for different duration on the hatchability and BW at hatch.

Therefore, the objective of this study was to identify the consequences of MF exposure of Japanese eggs with two intensities (750 and 1500 gauss) for different duration times (i.e., 0, 5, 10, 15, 20 and 25 min) before incubation on eggshell thickness, hatchability and chick BW at hatch of Japanese quail.

2.Materials and methods

2.1. Experimental design

The impacts of Japanese quail eggs exposure to MF before incubation on hatchability were investigated in 2 experiments. These two experiments were

.2 Magnetic field treatment

Two static magnetic intensities were produced by magnetize cylinder shape (Nefartary company, Industrial region, Ismailia Governorate, Egypt) for Japanese quail eggs (Figure 2.2.1). A cylindrical magnetic shape of 30 and 40 cm length and a diameter of 0.5 and 1.0 inch, respectively produced magnetic intensities of 750 and 1500 Gauss. Each magnetic apparatus was put in the center of white plastic cylinder and Japanese quail eggs were put around it. A hand-held Gauss meter(Hirst Magnetic Instruments, Ltd. UK; Figure 2.2.3) with Transverse probe Brand (model Gm07; accuracy ± 0.01%)was used to determine and assure the continuous exposure of the MF dose for Japanese quail eggs during the duration for each treatment.

carried out at the Inshas Poultry Research Station, Animal Production Research Institute, Agricultural Research Center, Egypt. Both experiments were performed in accordance with the guidelines of the institutional Ethics of Animal Use in Research Committee (EAURC), Cairo University, Egypt. A total of 1260 freshly laid eggs produced by Japanese quail flocks, at 35-weeks of age, were used in this study. In the first experiment, a factorial design (3x5) with 2-ways ANOVA with interaction was applied using 360 Japanese quail eggs that were divided into 15equal groups(3 replicates of 8 eggs per each group). Eggs were exposed to 3 intensities of MF (control 0, 750 and 1500 Gauss) and 5 durations of exposure (5, 10, 15, 20 and 25 min) before incubation. In the second experiment, one-way ANOVA was performed using 900eggs.

Eggs were divided randomly into 3 equal treatments (control vs. the best-selected treatments of the first experiment) with 10 replicates per each treatments (30 eggs per replicate).

2.3 Incubator procedure

Eggs of each treatment were separately set during a Mainor, force-draft incubator (Model II, Maino Enrico, Co., Rome, Italy) and incubated at 99.5°F (37.5°C) and 55%relative humidity. Eggs were transferred to separate compartments in the hatching tray on 15days of incubation, for chick identification at hatch. The hatching tray was divided into individual hatching compartments using thin sheets of wire mesh. Incubation procedures were almost as those published previously**[25]**. The Hatcher condition was 98.6°F (37°C) and 65%relative humidity until the top of day 18 of incubation, at which period chicks.

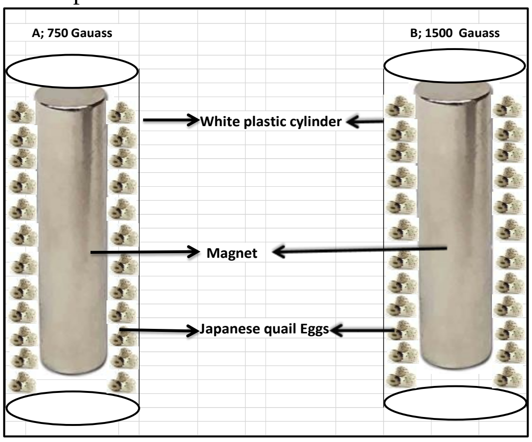

Figure 2.2.1. Static magnetic units that used in the experiment

Figure 2.2.3GM07 Gauss meter with Transverse probe

2.4.Collected data

Eggs were collected freshly, weighted and exposed to the treatments directly before incubation. To avoid the mal manipulation of eggs, eggs were weighted in groups then egg weight calculated by dividing the weight of egg group by the number of eggs per each group. At 10 days of incubation all eggs were exposed to identify the fertilized eggs by lighting test in a dark room. Fertility was calculated per each treatment. Hatchability was calculated for each treatment on the basis of the number of hatched chicks divided to the fertilized eggs of each treatment. Eggshell thickness was determined in eggs after broken. Each eggshell was washed with water then dried at room temperature of 25°C with paper towels. After hatch, 3 eggshell thickness measurements were taken from each eggshell with a micrometer (Ames, Waltham, MA, USA). Measurements of eggshell thickness were done with the membranes intact. Moreover, BW of each chick was measured.

2.5. Statistical analysis

Data in the first experiment was arranged to a 3x5 factorial randomized design and analyzed using two ways ANOVA with interaction **(26)**. However, the data in the second experiment were performed using complete randomized design and analyzed using one-way ANOVA. In the first experiment, egg weight and fertility rate were statistically analyzed and when the model is significant, they were added as a random effect (regression coefficient/covariant) in the model for all the other traits.

All percent data were transformed using arc sine square root percentage transformation before analysis. Linear and quadratic effects were performed to all data in the first experiment. When significant variance ratios were detected at $P<0.05$, differences among treatment means were tested using the least significant difference (LSD) procedure according to **(27)**. Results were presented as least square (LS) means$\pm$ standard error of the mean (SEM).

3. Results

3.1. First Experiment

Data in table (1) shown the ANOVA 2-ways with interaction statistics probabilities for egg weight and fertility rate of Japanese quail in the pilot experiment. Results indicated that egg weight and fertility rate data were significant ($P<0.0001$) which mean they are not homogeneous among treatment groups at the beginning of the experiment.

3.2. Eggshell thickness

Data presented in Table (2) reveals that that no significant effects of exposer Japanese quail eggs to MF doses (control, 750 and 1500 gauss) at different duration times (5,10,15,20 and 25 min) for egg shell thickness. Japanese quail eggshell thickness measured in the current research was ranged from 0.188 to 0.221 mm.

3.3. Hatchability and body weight (BW) at hatch

Data in Table (3)and Figure (3) presented the results of hatchabilityand chick body weight at hatch for Japanese quail in response to exposure of different MF doses (control, 750 and 1500 gauss) for different durations (5, 10, 15, 20 and 25 min). A significant interaction effect ($P<0.0001$)was observed between MF doses and the duration of MF exposure for hatchability. Results in table and figure (3) revealed that exposer of Japanese quail eggs at 750 or 1500 gauss caused an improvement as a positive impact on hatchability compared with control ones till 20 and 10 min, respectively. However, among duration within the same MF dose exposure this positive impact of 1500 gauss MF dose on hatchability was observed clearly until 10 min of exposure and after that, a negative effect was noted. A same negative impact was appeared after 20 min of exposure for the dose of 750 gauss, which cause the interaction effect noted between MF doses and the duration of MF exposure for hatchability of Japanese quail eggs.

Results in table (3) reveals that the hatchability and BW at hatch were significantly influenced by MF dose ($P<0.0001$). Moreover, positive significant linear effects were observed for hatchability in response to exposure eggs for different duration times to 750 and 1500 Gauss MF. Consequently, a linear effect was noted for hatchability and a quadratic effect was observed for BW at hatch in response to exposure eggs for different durations to 1500 Gauss MF. In addition, hatchability rate was significantly affected by duration time ($P<0.0001$). Over all mean in table(3)the highest effective duration was for 20 min followed by 10 min of MF exposure.

Table1. ANOVA2-ways with interaction statistics probabilities for egg weight and fertility rate of Japanese quail before the beginning of the experiment.

Item	**Egg weight (g)**	**Fertility rate (%)**
Model	<.0001	<.0001
Magnetic field (A)	0.4753	<.0001
Duration (B)	<.0001	<.0001
(AB)	<.0001	<.0001

Table 2. Effect of magnetic field (MF, Gauss) and exposure time (min) on eggshell thickness (mm) of *Japanese quail*

Duration (min)	**MF dose (Gauss)**			**Mean**
	0.0	**750**	**1500**	
5	0.18	0.19	0.21	0.19
10	0.20	0.20	0.22	0.20
15	0.19	0.20	0.20	0.20
20	0.20	0.21	0.20	0.20
25	0.20	0.20	0.20	0.20
Mean	**0.19**	**0.20**	**0.21**	**0.20**

No significant effects were detected for the main, interaction, linear, or quadratic effects at $P<0.05$.

Table 3. Effect of magnetic field (MF) and exposure duration on hatchability and chick body weight at one-day of age for Japanese quail

Duration (min)	**Hatchability (%)**				**Body weight (g)**			
	MF dose (Gauss)			**Mean**	**MF dose(Gauss)**			**Mean**
	0.0	**750**	**1500**		**0.0**	**750**	**1500**	
5	68.84**a**	70.20**e**	75.19**d**	**71.41c**	8.30	8.62	9.08	**8.67**
10	68.78**e**	74.87**d**	84.66**b**	**76.12b**	8.27	8.83	9.37	**8.82**
15	68.84**e**	75.90**d**	82.52**bc**	**75.75b**	8.30	8.99	9.25	**8.85**
20	69.62**e**	89.37**a**	80.32**c**	**79.77a**	8.23	9.18	9.22	**8.88**
25	68.84**e**	81.56**c**	77.39**d**	**75.93b**	8.39	8.83	9.16	**8.79**
Mean	**69.00C**	**78.38B**	**80.01A**	**75.79**	**8.30C**	**8.89B**	**9.22A**	**8.80**
Probabilities								
Model		<.0001				<.0001		
MF (A)		<.0001				<.0001		
Duration (B)		<.0001				0.3868		
(AB)		<.0001				0.3332		
Egg weight		0.1484				0.1842		
Fertility		0.3805				0.8569		
Linear	0.3230	0.0010	<.0001		0.9103	0.1212	0.0125	
Quadratic	0.5070	0.7430	<.0001		0.9932	0.5228	0.9438	

Means with different letter in the main effects or interaction cells are significant at $P<0.05$. ns = not significant; * = $P<0.05$; ** = $P<0.01$; *** = $P<0.001$.

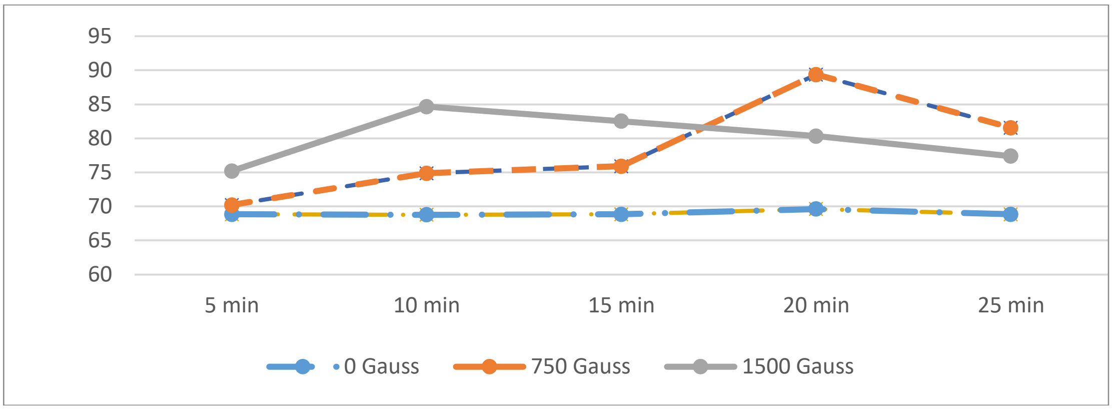

Figure 3.1.2 Effect of magnetic field (Gauss) and exposure duration (min) on hatchability rate (%) for fertilized *Japanese quail* eggs.

3.4 Second Experiment

Data presented in Table (4) showed that exposer Japanese quail eggs with 750 gauss for 20 min or 1500 gauss for 10 min caused an increase in hatchability by 17.4 and 17.9%, and BW at hatch by 4.84 and 7.20%, respectively compared to control group. on the other hand, no significant effects were observed for egg weight, fertility rate or shell thickness .Moreover, no differences were detected between MF doses (750 Gauss for 20 min and 1500 Gauss for 10 min) for hatchability and BW at hatch, which mean that the impacts are approximately equal.

Table 4. Effect of magnetic field (MF) treatments on egg weight, fertility rate, shell thickness (mm), hatchability rate and chick body weight (g) at 1 day of age for *Japanese quail*

	0.0	**MF dose (Gauss/min)**		**SEM**	***P* value**
Item		**750/20**	**1500/10**		
Egg weight (g)	13.17	13.19	13.21	0.15	ns
Fertility (%)	91.70	92.30	93.0	1.23	ns
Shell thickness (mm)	0.22	0.21	0.20	0.03	ns
Hatchability (%)	77.5b	91.0a	91.4a	2.24	**
Body weight (g)	7.64b	8.01a	8.19a	1.20	*

Means with different letter in the same row are significant at $P<0.05$. SEM = Standard error of the mean (n=300); ns = not significant ($P>0.05$); * = $P<0.05$; ** = $P<0.01$.

4. Discussion

4.1. Egg weight and fertility rate

Egg weight and fertility rates are expected to be equal or homogeneous among the treatment groups and not affected by treatments as they occurred and obtained before the beginning of treatments. Data of the first experiment showed that egg weight and fertility rate of Japanese quail were not homogeneous among treatment groups before the beginning of the experiment. Therefore, both traits were added as random effects in the model for all the other traits in this experiment as recommended by**(28)**.However, in the second experiment no significant effect was detected for both traits, which means that they were homogeneous among treatment groups.

4.1Eggshell thickness

Eggshell thickness values were ranged from 0.18 to 0.22 mm in both experiments of the current research study.These findings are in accordance with what is well known that the mean average of eggshell thickness has been reported to range between 0.17 and 0.40 mm, for quail eggs[**29,31**],a layer-type breeder**[30].** In the same context **Ergün and Yamak(2017)[32]**reported that eggshell thicknesses were ranged between 0.24 and 0.36 mm, for Japanese quail eggs revealed from flocks aged 23 and 41 weeks of age. The differences between these ranges and what obtained in this study might be attributed to the different managerial conditions or the BW of the quails.
The information available in the research regarding the impact of MF dose or duration of exposure on eggshell thickness is rare. **Shafey *et al.* (2007)[30].**reported that eggshell thickness of eggs from a layer-type breeder was affected by egg size.

In addition, they noted that eggshell thickness play a great role in water loss from eggs during the incubationperiod. Moreover, as mentioned before the MF affects the water proprieties. In the same line, egg weight was significantly different among the experimental groups in experiment 1 in the current research. Therefore, the authors expect an indirect impact of MF on eggshell thickness. However, the eggshell thickness in the current research was not affected by MF dose or duration of exposure. These findings may be due to the time of the exposure (before- in the current research and during- in and the different species used in both studies (quail vs. fowl), respectively **[30].**

4.2. Hatchability and BW at hatch

Ergün and Yamak (2017)[32]reported that the hatchability of thin-, medium-, and thick-shelled eggs was ranged as 69.2-87.8%, 69.4-89.2%, and 82.4-91.9% for Japanese quail eggs revealed from flocks aged 23 and 41 weeks of age, respectively. These findings are in accordance with the obtained results from the current study as hatchability values were ranged from 68.8 to 91.4% in both experiments.

Data for the first experiment shows that hatchability rates were increased by 13.4 and 15.7% and values of BW at hatch were increased by 7.1 and 11.1% when MF dose increased from 750 to 1500 Gauss, respectively (Table 3). These findings were supported by the linear effects for hatchability at 750 and 1500 Gauss and at 1500 Gauss for BW at hatch. Moreover, a quadratic effect observed for hatchability at MF of 1500 Gauss supporting that. In addition, data of the second experiment, in Table (4) confirmed these positive impacts of MF doses (750/20 min and 1500/10 min, respectively) on hatchability and BW at hatch. However, no differences were detected between both MF doses, which mean that the impacts are approximately equal. These obtained results confirmed the positive impacts on hatchability and BW at hatch in response to increase MF dose, which is in agreement with **Tarasewicz *et al.* (2006) [23]**who observed improvement in hatchability of Japanese quail eggs when studied the effect of magnetic flux on embryogenesis in poultry. Moreover, **Veterany, and Jedlicka(2001) [33], [34]**reported an increase in hatchability of eggs subjected to MF of 0.07 T (700 Gauss) during storage (before hatching) for 20–40 min. These obtained results are of great interest because it takes place outside the native organism, which is inconvenient with the experiment conditions of this study. In addition **El-Sabry *et al.* (2018)**, **[24]**found that hens' eggs exposed to magnetic flux showed absolutely the simplest values of hatching indices. In the same context, **Ibrahim *et al*[18]**observed improvements in hatchability and BW at 1 and 4 weeks of age in response to exposure quail eggs to 110 Gauss MF during the either first or second week of the incubation period. Recently,**Younis and Qasim[17]** reported substantial increase in hatchability and live BW until 42 days of age when Ross 308 broiler breeders' eggs were exposed to 1800 Gauss MF for 30, 60, and 90 min. Also,**Piera*et al.* (1992)[35]r**eported that continuous exposure to MF increased embryos weight at 15-d of age which might explain at least in part the significant increase of BW at hatch by increasing the dose of MF in the current research.

The mechanisms of the positive impacts of MF on hatchability and BW at hatch might be due to the changes occurred in the physical characteristics of egg water in response to MF exposure. **Al-Mosely (2013**)[**21**]noted that the MF improves the physical characteristics of eggs' water by 65 to 70%. For example, the surface area of water increases and the water tension surface decreases by exposing eggs to MF, which causes increment of nutrient transfer and toxic absorption by increasing the solubility and diffusion[**20**]. Moreover, **Wit and Dańczak [36]** found that subjecting the eggs in incubation period to short term influence of high-induction MF caused definite changes in the process of embryogenesis and chick clutching. In addition, **Lahijani *et al.*(2007)[37]**reported that the pre-incubated White leghorn exposed chick embryos to MF were affected at the morphological and cellular levels, nuclei and the most affected part is the telencephalon, especially the brain and eye. All these, mode of actions might cause changes in specific gene transcription as noted early by**[38]** and **[39]**and recently by**[40].**

On the other hand, results of the hatchability of eggs reported in the current research were not in accordance with **[41]**who found that exposing of chicken embryos to an intermittent 200 lT (2 Gauss) MF at 50 Hz did not influence hatching weight of chickens. In addition, **Shafey *et al.*[42]** reported that the effects of exposing meat-type breeder eggs to MF of 18 Gauss at 50 Hz for up to 75 min before incubation on the hatchability traits did not influence hatchability traits and chick weight at hatch .Moreover, **Scripnic and Modvala[43]**did not found any effect of MF on hatchability for hen eggs. Consequentially, the results obtained for chick weight at hatch were inconvenience with **[44]**who noted a reduction in chick weight at hatch when eggs were exposed to MF of 0.04 T (400 Gauss) daily for 10 s during incubation. Also, these results were supported by**[45]**who reported that exposing chicken embryos to MF of 1, 500, and 10,000uT (0.01, 5, and 10 Gauss) at 50 Hz for 15 or 21 d reduced embryo weight at 15 or 21 d. Moreover, **Shafey *et al* .[42]**found that exposing meat-type breeder eggs to MF of 18 Gauss (1.8 mT) at 50 Hz for up to 75 min did not influence the hatchability of eggs and chick weight at hatch but hatched chicks from eggs exposed to MF for 60 and 75 min had lower weight gain and feed intake than those of the non-exposed treatment at 39 days of age. In the same context, **Shafey *et al.*[16]** found that short term exposure of layer-type breeder eggs to MF of 7.5 Gauss (0.75 mT) at 50 Hz, for up to 60 min before incubation didn't influence the characteristics of egg contents, embryonic growth, hatching time, and hatchability of eggs. Magnetic field (MF) exposure of eggs for 40 and 60 min increased egg weight loss during incubation and hatching weight of chickens.

controversies among researches might be attributed to several reasons 1] the different doses of MF, 2] the time (before or during the incubation),3] the duration of exposure eggs to MF, 4] the way of delivering MF (in water or by direct exposure to eggs), 5] the equipment (apparatus model), 6] the handling of MF exposure,7] the studied breed species (for example: fowl or quail),and/or 8] the incubation different managerial conditions.

5. CONCLUSION

It could be concluded from this study that MF dose up to 1500 Gauss for 25 min had nosignificant effects on eggshell thickness. However, positive impacts of MF dose on hatchability and BW at hatch of Japanese quail were clearly noted in both experiments. From the first experiment, the linear effects for hatchability at 750 and 1500 Gauss and only at 1500 Gauss for BW at hatch supported these positive impacts. Consequentially, a quadratic effect was observed for hatchability at MF of 1500 Gauss .Moreover, the suggested MF doses: 750 Gauss for 20 min and 1500 Gauss for 10 min from results of first experiment had the same impact for hatchability and BW at hatch as indicated in the second experiment. Therefore, it is recommended for quail breeders to implement in their hatcheries the most effective andefficient treatment, which is either 750 Gauss/20 min or 1500 Gauss/10min.

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