Scientific Research and Essays Vol. 7(25), pp. 2205-2212, 5 July, 2012
Available online at http://www.academicjournals.org/SRE
DOI: 10.5897/SRE11.2012
ISSN 1992-2248 ©2012 Academic Journals

*Full Length Research Paper*

# Effects of short term exposure of layer-type breeder eggs to magnetic field on hatchability and hatching parameters

**Shafey T. M.[1]*, M. A. Alodan[1], M. M. Ghannam[2], M. A. K. Abdelhalim[2] and M. M. Mady[2]**

[1]Department of Animal Production, College of Food and Agriculture Sciences, King Saud University, P. O. Box 2460, Riyadh 11451, Saudi Arabia.
[2]Department of Physics, College of Sciences, King Saud University, P. O. Box 2460, Riyadh 11451, Saudi Arabia.

Accepted 25 April, 2012

**Two trials were conducted to investigate the effects of short term exposure of layer-type breeder eggs to magnetic field (MF) of 7.5 Gauss (0.75 mT) at 50 Hz, for 0, 20, 40 and 60 min before incubation on the characteristics of egg contents, egg weight loss, embryonic growth and hatching time (Trial 1) and hatchability of eggs (Trials 1 and 2). 384 and 240 Leghorn and Baladi eggs were used in trials 1 and 2, respectively. Treatments were replicated 4 times in the two trials. Exposing Leghorn eggs to MF did not influence weight of egg contents, eggshell thickness, albumen and yolk heights, embryo weight, hatching time and hatchability of eggs. Eggs exposed to MF for 40 and 60 min had higher weight loss percentage and chick hatching weight when expressed on the basis of absolute value. It can be concluded 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 did not influence the characteristics of egg contents, embryonic growth, hatching time, and hatchability of eggs. MF exposure of eggs for 40 and 60 min increased egg weight loss during incubation, and chick weight at hatch day.**

**Key words:** Magnetic field, layer eggs, embryonic growth, hatchability.

## INTRODUCTION

The use of electrical devices around us has resulted in a great interest in the biological effects of the electromagnetic fields (EMF) radiated from these devices. Magnetic field (MF) is part of the electromagnetic spectrum. All living organisms (almost) are exposed to MF from various sources. MF affects various biological functions of living organisms, for example, DNA synthesis and transcription (Phillips et al., 1992), as well as ion transportation through cell membranes (Liburdy et al., 1993). The geomagnetic field on the surface of the earth is approximately 0.50 to 0.75 Gauss (0.05 to 0.075 mT) at 50 Hz in strength. The detectable limit of interaction between higher animals and a stationary MF is 80 to 100 Gauss (8 to 10 mT) (Ketchen et al., 1978).

The body of birds is formed by many cells that communicate with the environment through information transfer carried out by electric impulses or chemical substances. The body EMFs from the biological structures are characterized by certain specific frequencies that can be interfered with by the EMF radiation, through induction and causing modification in their biological responses, and capable of morphological change and metabolism, growth and reproduction (Hyland, 2000). Animals exposed to the EMF can suffer a deterioration of health, changes in behaviour (Marks et al., 1995; L'oscher and K'as, 1998), and reproductive

*Corresponding author. E-mail: tmshafey@ksu.edu.sa. Tel: 966-1-4678785. Fax: 966-1-4678474.

success (Doherty and Grubb, 1996; Fernie et al., 2000). EMF exposure affected the reproductive success of kestrels (*Falco sparverius*), increasing fertility, egg size, embryonic development and fledging success but reduced hatching success (Fernie et al., 2000). Birds are especially sensitive to MFs (Liboff and Jenrow, 2000). Grigoriew (2003) reported a high mortality rate of chicken embryos subjected to the radiation from a cell phone when compared with those of the control group. Exposing chicken embryos to pulsed MFs increased mortality (Youbicier-Simo and Bastide, 1999) and morphological abnormalities, especially of the neural tube (Ubeda et al., 1983, 1994; Farrell et al., 1997). Recently, Shafey et al. (2011) 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. However, 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.

There is lack of information regarding the effects of MF on the hatchability traits of layer type breeder eggs. The objectives of this study were to examine the effects of MF before incubation of layer-type breeder eggs on the characteristics of eggs, embryonic development, hatchability, hatching time and chick weight at hatch day.

## MATERIALS AND METHODS

The effects of exposure of fertile eggs to MF before incubation on the characteristics of egg contents, embryonic growth and hatchability of layer-type breeder eggs were investigated in 2 trials. A total of 384 freshly laid eggs produced by a layer-type breeder flock (Leghorn, King Saud University), at 50-weeks of age were used in trial 1. Birds were fed a standard breeder ration (16% CP, 2866 kcal/kg of ME per kg, 3.4% calcium, 0.45% available phosphorus) and reared under standard husbandry conditions. A photoperiod of 14 h commenced when the birds were caged at 22 weeks of age and was maintained throughout the trials. Eggs were numbered, weighed individually, distributed into weight classes and assigned into 16 replicates of 24 eggs each. Four replicates were randomly assigned to each of the four experimental treatments. The treatments were non-exposed control (MF0) or exposed to MF of 7.5 Gauss (0.75 mT) at 50 Hz for 20, 40 and 60 min (MF20, MF40 and MF60) before incubation. Twelve eggs from each treatment were selected at random to investigate the effects of MF on the quality and characteristics of egg contents. Eggs were broken, albumen and yolk separated, weighed and then percentage of albumen and yolk were calculated (percent albumen = albumen weight/egg weight*100, and percent yolk = yolk weight/egg weight*100, respectively). Egg shells were washed with water, dried at room temperature of 25℃ with paper towels, weighed and then percent eggshell was calculated (percent eggshell = eggshell weight/egg weight*100). Three eggshell thickness measurements were taken from each eggshell with a micrometer (Ames, Waltham, MA, USA). Measurements of eggshell weight and eggshell thickness were done with the membranes intact. The remaining eggs were incubated and four eggs per treatment were removed for egg weight loss and embryo weight measurements on day 7, 14, and 18 of incubation. Eggs were weighed, broken open, and embryos were separated and weighed individually after removing the yolk sac and placing it on a paper tissue to dry. Percents of egg weight loss and embryonic weight were calculated (percent egg weight loss = (1-egg weight after incubation/egg weight before incubation)*100, and percent embryo = embryo weight/egg weight before incubation*100, respectively). Measurements were made of egg contents and characteristics (weight of albumen, yolk, and eggshell, eggshell thickness, and height of albumen and yolk), embryonic growth and egg weight loss during incubation, percents of hatchability and hatchability failures (pips with live embryos, pips with dead embryos, dead embryos), and hatching time.

The incubation trial was repeated with different strain of eggs. A total of 240 eggs produced by a layer-type breeder flock (Baladi, King Saud University), at 53-week of age were used in this trial. Husbandry conditions of the flock were similar to those of the Leghorn flock. Eggs were evenly assigned into 16 replicates of 15 eggs of equal weight per each replicate. Replicates were assigned to the four treatments as in trial 1. Measurements were made of percentages of hatchability and hatchability failures (pips with live embryos, pips with dead embryos, dead embryos).

### Magnetic field

A homogenous MF was generated by four solenoids of 270 turns each of electrically insulated copper coil of 2.2 mm, wound around a parallel double walled cylindrical chamber from copper of 2 mm thick and internal and external diameter of 45 and 55 cm, respectively (Figure 1). The four coils are connected in parallel to minimize the total impedance of the wire and to get a homogeneous MF within the chamber volume. The coils are connected to a variac fed from the main power outlet (220 $V_{pp}$ and 50 Hz). The strength of MF was controlled and varied by the variac. The MF inside the chamber is measured at different locations in order to find out the most homogenous zone inside the chamber. A hand-held Gauss/Tesla Meter Model 4048, with probe T-4048-001 (USA) of accuracy ± 2% is used to calibrate the MF. Homogeneity of MF under different field intensities is shown in Figure 2.

The space between the double walled cylindrical chamber was sealed with an inlet and outlet to permit water flow between the two cylinders in order to keep the temperature of the chamber constant during the exposure period. The temperature of the flowing cooling water at the outlet of the jacket and the temperature inside the irradiation chamber were constantly measured through the use of thermocouple thermometer, which can give reading for the temperature variations within ± 0.1℃. There was no difference in temperature between the room and the chamber.

### Incubation of eggs

Eggs were set in a Maino, force-draft incubator (Model II, Maino Enrico, Co., Rome, Italy) and incubated at 99.5℉ (37. 5℃) and 55% relative humidity. Eggs were transferred to separate compartments in the hatching tray on 19 days 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 similar to those published previously (Shafey et al., 2005b), in which eggs were examined by candling at days 6 and 14 of incubation, and clear eggs and eggs containing dead embryos were removed. Early dead embryos were counted from days 1 to 14 of incubation. The hatcher condition was 98.6℉ (37° C) and 65% relative humidity until the end of day 21 of incubation, at which time chicks, pips (unhatched eggs with live or dead chicks) and late dead embryos (unhatched eggs with unbroken shell) were counted. Late dead embryos were counted from day 14 to the end of day 21,

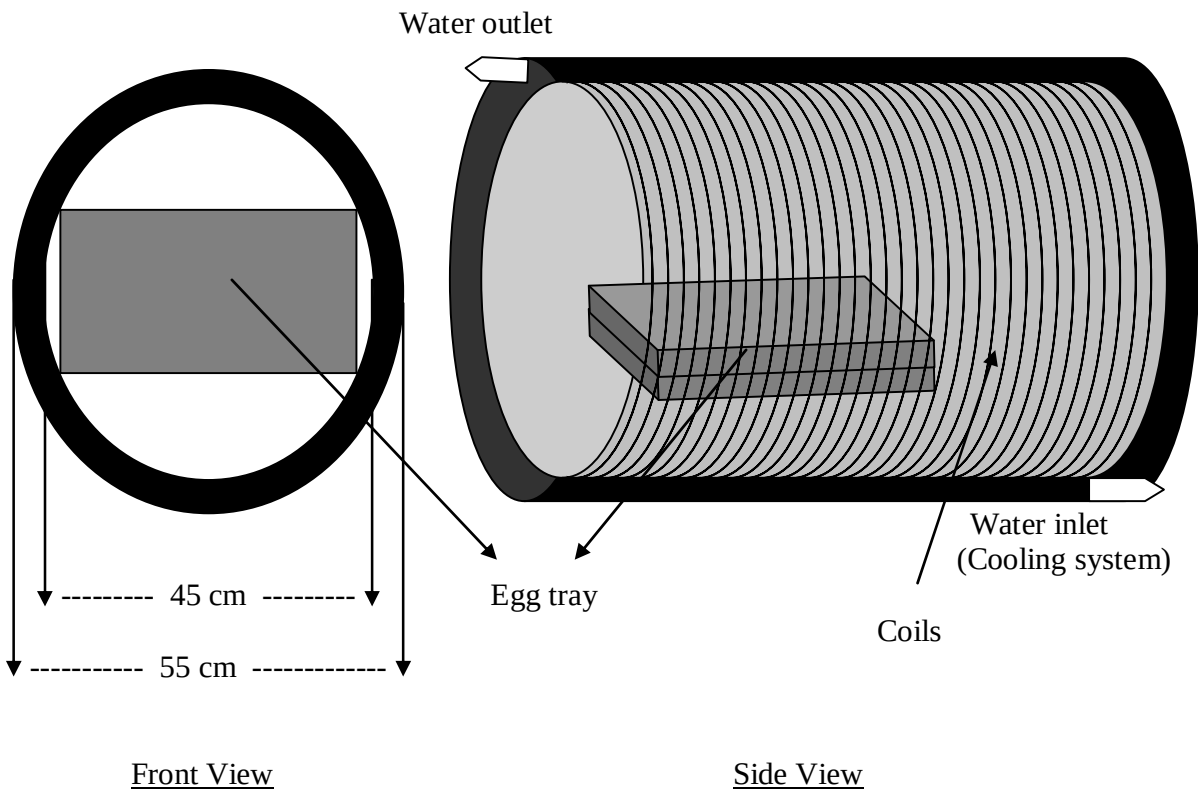


**Figure 1.** Magnetic field.

when incubation ended. Percentage of hatchability was calculated on the basis of the number of hatched chicks as a per cent of the number of fertile eggs per treatment. Hatching time was recorded every 24 h in the first trial. Chicks were removed every 24 h intervals from 432 to 504 h of incubation and hatching weight were recorded by scale with 0.1 g accuracy. Percent of hatched chicks over each interval of 24 h was calculated as percentage of the total number of hatched chicks over the whole incubation period.

Data on egg contents, and characteristics, and chick hatching weight (trial 1), hatchability (trials 1 and 2) were subjected to a one-way ANOVA. Data on egg weight loss, and embryonic weight were arranged in 4 × 3 factorials with four levels of treatments [0 (non-exposed eggs, control), 20, 40, and 60 min of MF] and three days of incubation (days 7, 14 and 18) as main effects and their two-way interactions fitted into the model. All percent data were transformed using arc sine square root percentage transformation before analysis. When significant variance ratios were detected, differences between treatment means were tested using the least significant difference (LSD) procedure. All statistical analysis was performed using the Statistical Analysis System (SAS Institute, 1985).

## RESULTS

The effects of exposing layer-type breeder eggs to MF of 7.5 Gauss (0.75 mT) for up to 60 min before incubation on the characteristics of egg contents, weight of embryos, egg weight loss, hatchability and hatchability failures (early or late dead embryos and pips with live or dead chicks), chick hatching weight and length of incubation are shown in Tables 1 to 4, respectively (trial 1). There were no significant differences in the percentage of albumen, yolk, eggshell, and embryo weights in the egg, eggshell thickness, egg albumen, and yolk heights, and percentages of hatchability and hatchability failures, and incubation period. Eggs of MF40 and MF60 had significantly ($P < 0.05$) higher weight loss percentage during incubation and chick weight when expressed on the basis of absolute value (g) than those of MF0, whilst percent of egg weight loss and chick hatching weight (g) of MF20 were intermediate. Age of embryo significantly ($P < 0.01$) influenced percent of egg weight loss and embryo weight. Embryos at older age had higher percent of egg weight loss and body weight when compared with those of younger age (18 days < 14 days < 7 days). Percent of chick hatching weight of MF40 was significantly ($P < 0.05$) higher than those of MF0, whilst percent of chick hatching weight of MF20 and MF60 was intermediate. Percent of hatched chicks of MF40 and

MF60 was higher at 456 h of incubation and lower at 480 h of incubation than those of MF0 and MF20 (trial 1).



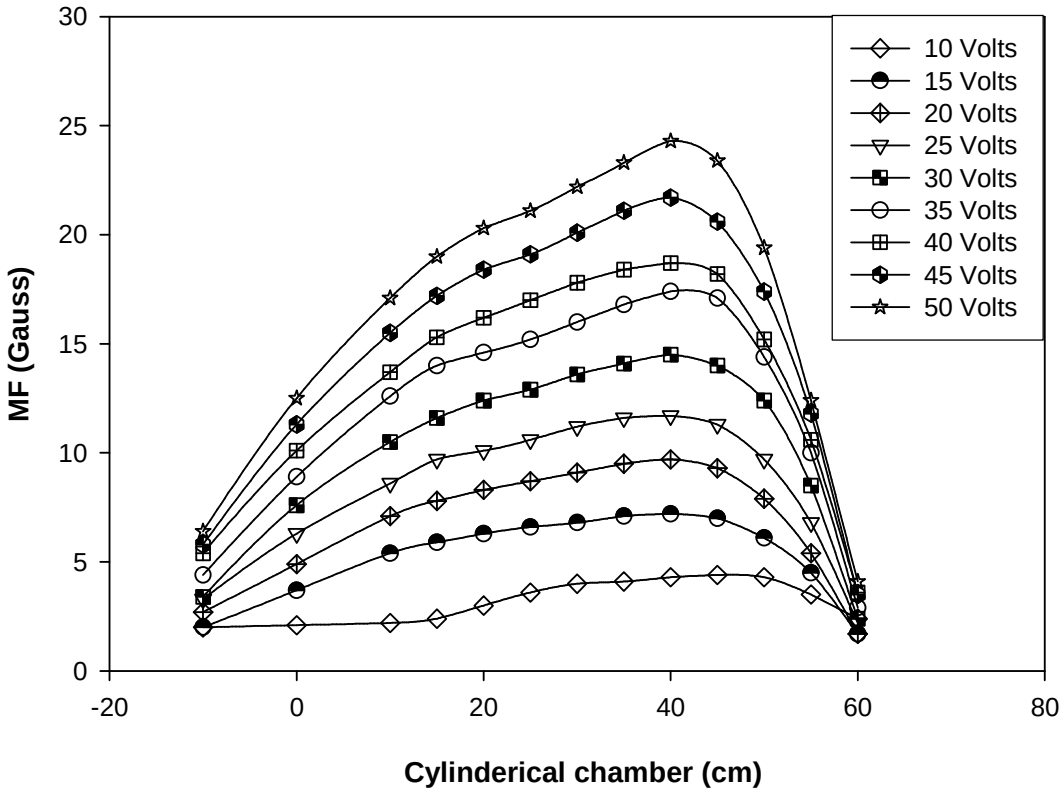


**Figure 2.** Homogeneity of magnetic field (MF) inside the cylindrical chamber under different field intensities.

The effects of exposing Baladi eggs to MF of 7.5 Gauss (0.75 mT) for up to 60 min before incubation on hatchability and hatchability failures are shown in Table 5 (trial 2). Exposing Baladi eggs to MF did not significantly influence percents of hatchability and hatchability failures of eggs.

## DISCUSSION

Results from this study indicated that exposing layer-type breeder eggs to MF of 7.5 Gauss (0.75 mT) for up to 60 min before incubation did not influence the egg contents and its characteristics, embryonic growth, hatchability, hatchability failures and incubation period (trial 1). Eggs exposed to MF for 40 and 60 min had higher weight loss per cent during incubation and chick hatching weight when expressed on the basis of absolute value than those of the non-exposed treatment by approximately 10.4 and 1.2, and 14.4 and 1.2%, respectively (trial 1). The effects of MF on the chicken embryo weight and chick weight at hatch day are in agreement with Koch and Koch (1991) who reported no effects for MF of pulsed waveforms and 50 Hz sinusoidal fields on embryos. Similarly, Cox et al. (1993) reported no effect on the development of chicken embryos when eggs were exposed to MF of 10 µT, 50 Hz in the first 52 h of incubation. The effect of MF on chick weight was in agreement with Pierra et al. (1992) who reported an increase in chick weight at hatch day. In contrast, several studies reported that MF affected early development of chicken embryos, and increased malformation (Delgado et al., 1982; Juutilainen, 1986; Juutilainen and Saali, 1986; Juutilainen et al., 1986, 1987; Farrell et al., 1997), and hatchability of chicken eggs exposed to MF before incubation, and reduced hatchability and chick weight from eggs exposed to MF during incubation (Toman et al., 2002), and had no affect on chick hatching weight (Veicsteinas et al., 1996; Shafey et al., 2011). These studies on the effects of MF on chicken embryos, hatchability and chick hatching weight have been reported in the literature, but evaluation of the consistency of the findings is difficult due to the varying methods, periods of exposures, approaches used in different studies and strain of bird.

The increase in chick weight at hatch day in this experiment may have resulted, partly from the difference

in egg weight loss during incubation. Shafey et al. (2005a, 2007) reported that incubation of eggs under the influence of electric field of 30 Kv/m at 60 Hz significantly increased the percentage of egg weight loss and chick-



**Table 1.** Egg contents, eggshell thickness and albumen and yolk heights of layer-type breeder (Leghorn) eggs exposed to magnetic field (MF) of 7.5 Gauss before incubation for up to 60 min (Trial 1) [1].

| MF treatment (min) | Egg weight (g) | Albumen weight (%)[2] | Yolk Weight (%)[2] | Shell weight (%)[2] | Shell thickness* 100 (mm) | Albumen height*10 (mm) | Yolk height *10 (m m) |
|---|---|---|---|---|---|---|---|
| 0 | 55.4 ± 1.80 | 59.7 ± 0.80 | 30.7 ± 0.91 | 9.5 ± 0.21 | 38 .7 ± 1.32 | 80.2 ± 2.27 | 53.0 ± 2.81 |
| 20 | 55.9 ± 1.61 | 58.5 ± 1.46 | 31.9 ± 1.21 | 9.6 ± 0.45 | 37.4 ± 1.69 | 73.7 ± 2.85 | 52.3 + 3.50 |
| 40 | 55.1 ± 2.02 | 59.5 ± 0.74 | 30.6 ± 0.68 | 9.8 ± 0.11 | 39.2 ± 0.25 | 76.7 ± 3.00 | 52.4 + 2.84 |
| 60 | 55.7 ± 1.78 | 58.8 ± 1.51 | 31.8 ± 1.68 | 9.4 ± 0.26 | 39.0 ± 1.58 | 72.4 ± 6.53 | 52.4 + 3.42 |
| Probability | NS | NS | NS | NS | NS | NS | NS |

[1], Values are means ± SE of 12 eggs; [2], As a percentage of egg weight; NS= Not significant (P > 0.05).

**Table 2.** Mean percent of egg weight loss, and embryo weight of layer-type breeder eggs (Leghorn) exposed to magnetic field (MF) of 7.5 Gauss before incubation for up to 60 min (Trial 1) [1].

| Treatment | Egg weight (g) | Egg weight loss (%)[2] | Embryo weight (%)[2] |
|---|---|---|---|
| MF (T) (min) | | | |
| 0 (18) | 55.24 ± 0.95 | 9.04 ± 0.72[b] | 18.41 ± 3.76 |
| 20 (18) | 55.39 ± 0.83 | 9.64 ± 0.79[ab] | 18.80 ± 3.88 |
| 40 (18) | 54.90 ± 0.82 | 9.98 ± 0.89[a] | 18.73 ± 3.84 |
| 60 (18) | 54.34 ± 1.07 | 10.34 ± 1.06[a] | 19.72 ± 3.80 |
| Embryonic age (day) | | | |
| 7 (24) | 55.33 ± 0.84 | 5.58 ± 0.17[c] | 1.13 ± 0.04[a] |
| 14 (24) | 54.3 ± 0.67 | 10.04 ± 0.28[b] | 15.96 ± 0.31[b] |
| 18 (24) | 55.32 ± 0.86 | 13.63 ± 0.45[a] | 38.87 ± 0.74[a] |
| T | NS | P < 0.05 | NS |
| Age | NS | P < 0.0001 | P < 0.0001 |
| T × Age | NS | P < 0.05 | NS |

[1], Values are means ± SE of the number of replicates given in parentheses; [2], As a percentage of egg weight. [a,b,c], Means within column followed by different superscripts are significantly different (P < 0.05); NS= Not significant (P > 0.05).

hatching weight of Baladi eggs by approximately 18.4 and 1.7%, respectively. Egg weight loss during incubation is very important for embryonic growth and development (Rahn and Ar, 1974; Rahn et al., 1981), and consequently, hatchability (Meir et al., 1984). However, it seems that the increase in egg weight loss during incubation of MF treated eggs was not enough to influence hatchability and hatchability failures of eggs (Romanoff, 1930; Peebles and Brake, 1985). MF exposure of eggs for 20, 40 and 60 min reduced albumen height by approximately 8.1, 4.4 and 9.7% (Table 1), respectively, albeit non-significantly, may indicate that MF exposure of eggs before incubation tended to increase the liquefaction of albumen of eggs and consequently vital gas exchange. Meuer and Baumann (1988) and Brake et al. (1993) suggested that thick albumen might interfere with gas exchange during early incubation. In this study, eggs of comparable weights, contents, and eggshell thickness were used (Table 1). This finding may suggest that MF exposure of eggs before incubation increased the evaporation rate of water from eggs and consequently increased egg weight loss. The improvement of evaporation rate of water from the incubated egg may improve the capacity of eggshell to vital gas exchange and consequently, support oxygen consumption of the embryo.

Results indicated exposure of eggs to MF for 40 and 60 min before incubation increased percent of hatching chicks within 456 h of incubation by approximately 85.7 and 98.6%, respectively and reduced percent of hatching chicks within 480 h of incubation by approximately 29.7 and 15.6%, respectively, without any significant effect on

the length of incubation when compared with those of the control (Table 4). It appears that exposing layer-type eggs to MF for 40 and 60 min increased egg weight loss, chick hatching weight (g), and hatching rate of chicks at456 h of incubation and tended to increase chick weight percentage and liquefaction of albumin, albeit non-

**Table 3.** Mean percent of hatchability, hatchability failures, egg weight and chick hatching weight express on an absolute and percentage basis (chick hatching weight*100/egg weight) of layer-type breeder eggs (Leghorn) exposed to magnetic field (MF) of 7.5 Gauss before incubation for up to 60 min (Trial 1)[1].

| MF treatment (min) | Hatch of fertile (%)[2] | Early dead embryo (%) | Late dead embryo (%) | Pipped with live embryos (%) | Pipped with dead embryos (%) | Egg weight (g) | Chick weight (g) | Chick weight (%) |
|---|---|---|---|---|---|---|---|---|
| 0 | 84.48 ± 2.04 | 1.39 ± 1.39 | 11.27 ± 0.16 | 1.47 ± 1.47 | 1.39 ± 1.39 | 55.44± 0.51 | 36.88 ± 0.37[b] | 66.41 ± 0.28[b] |
| 20 | 87.17 ± 4.97 | 4.33 ± 2.80 | 8.50 ± 3.63 | 0.00 ± 00.00 | 0 .00 ± 00.00 | 55.33 ± 0.47 | 36.85 ± 0.32[ab] | 66.63 ± 0.26[ab] |
| 40 | 80.15 ± 3.91 | 10.05 ± 5.03 | 8.41 ± 3.66 | 1.39 ± 1.3 9 | 0.00 ± 00.00 | 55.32 ± 0.49 | 37.31 ± 0.38[a] | 67.45 ± 0.32[a] |
| 60 | 85.78 ± 2.45 | 5.71 ± 0.16 | 8.50 ± 2.61 | 0.00 ± 00.0 | 0.00 ± 00.00 | 55.46 ± 0.59 | 37.31 ± 0.50[a] | 67.23 ± 0.41[ab] |
| Probability | NS | NS | NS | NS | NS | NS | P < 0.05 | P < 0.05 |

[1], Values are means ± SE of 4 replicates with 21 eggs in each replicate. There was no significant difference in the percentage of fertile eggs (mean ± SE) between treatments (95.8 ± 1.39, 98.6 ± 1.39, 97.2 ± 2.78, and 98.6 ± 1.39, for eggs exposed to MF for 0, 20, 40 and 60 min, respectively, NS= Not significant (P > 0.05).

**Table 4.** Incubation period of layer-type breeder eggs (Leghorn) exposed to magnetic field (MF) of 7.5 Gauss before incubation for up to 60 min (Trial 1)[1].

| MF treatment (min) | Incubation period (h) | Hatching distribution over the incubation period (%) | | |
|---|---|---|---|---|
| | | Incubation period (h) | | |
| | | 456 | 480 | 504 |
| 0 | 475.0 ± 2.99 | 21.0 ± 12.46[b] | 79.0 ± 12.46[a] | 0.0 ± 0.00 |
| 20 | 475.5 ± 2.52 | 21.8 ± 9.01[b] | 75.3 ± 7.60[a] | 2.9 ± 1.71 |
| 40 | 471.9 ± 0.86 | 39.0 ± 5.05[a] | 55.5 ± 6.72[b] | 5.4 ± 1.86 |
| 60 | 472.7 ± 0.47 | 41.7 ± 4.81[a] | 47.1 ± 11.35[b] | 11.2 ± 6.57 |
| Probability | NS | P < 0.0201 | P < 0.0031 | NS |

[1] Values are means ± SE of hatching hour; NS= Not significant (P > 0.05).

**Table 5.** Mean percent of hatchability and hatchability failures of layer-type breeder eggs (Baladi) exposed to magnetic field (MF) of 7.5 Gauss before incubation for up to 60 min (Trial 2)[1].

| MF treatment (min) | Hatch of fertile (%)[2] | Early dead embryo (%) | Late dead embryo (%) | Pipped with live embryos (%) | Pipped with dead embryos (%) |
|---|---|---|---|---|---|
| 0 | 87.48 ± 3.41 | 6.39 ± 1.69 | 3.66 ± 1.63 | 2.47 ± 1.68 | 0. 00 ± 0.00 |
| 20 | 85.17 ± 4.18 | 4.33 ± 1.91 | 6.50 ± 2.31 | 2.50 ± 1.25 | 1.50 ± 1.500 |
| 40 | 83.15 ± 3.98 | 5.05 ± 3.09 | 8.41 ± 2.79 | 1.31 ± 1.31 | 2.08 ± 2.08 |
| 60 | 86.78 ± 2.44 | 6.50 ± 1.96 | 5.51 ± 2.61 | 1.21 ± 1.09 | 0.00 ± 00.00 |
| Probability | NS | NS | NS | NS | NS |

[1] Values are means ± SE of 4 replicates with 15 eggs in each replicate. There was no significant difference in the percentage of fertile eggs (mean ± SE) between treatments (97.6 ± 1.32, 98.4 ± 1.79, 96.9 ± 2.13, and 97.9 ± 1.89, for eggs exposed to MF for 0, 20, 40 and 60 min, respectively; NS= Not significant (P > 0.05).

significantly. These results may suggest that exposure of eggs to MF for 40 and 60 min improved the characteristics of egg contents leading to increased eggshell conductance and gas exchange (Christensen et al., 1996), and increased the efficiency of transfer of nutrients from the eggs, and consequently enhanced nutrient utilization by embryos.

It can be concluded that MF exposure of eggs to MF of 7.5 Gauss at 50 Hz for up to 60 min for layer breeder eggs did not influence the characteristics of egg contents, hatchability and hatchability failures of eggs. MF of 7.5 Gauss at 50 Hz exposure of eggs for 40 and 60 min increased egg weight loss during incubation, and hatching weight of chickens.

## ACKNOWLEDGEMENTS

The authors extend their appreciation to the Deanship of Scientific Research at King Saud University for funding the work through the research group project No RGP-VPP-121. The authors would like to thank E.O.S. Elkordy for his technical assistance.

### REFERENCES

Brake J, Walsh TJ, Vick SV (1993). Relationship of egg storage time, storage conditions, flock age, eggshell and albumen characteristics, incubation conditions, and machine capacity to broiler hatchability-Review and model synthesis. Zootec. Int., 16: 30-41.

Christensen VL, Davis GS, Lucore LA (1996). Eggshell conductance and other functional qualities of ostrich eggs. Poult. Sci., 75: 1404-1410.

Cox FC, Brewer LJ, Raeman CH, Schryver CA, Child SZ, Carstensen EL (1993). A test for teratological effect of power frequency magnetic fields on chick embryos. IEEE T. Bio-Med. Eng., 40: 605-610.

Delgado JMR, Leal J, Montagudo JL, Gracie G (1982). Embryological changes induced by weak, extremely low frequency electromagnetic fields. J. Anat., 134: 533-551.

Doherty PF, Grubb TC (1996). Effects of high-voltage power lines on birds breeding within the power lines' electromagnetic. Sialia, 18: 129-134.

Farrel JM, Litovitz TL, Penafiel M (1997). The effect of pulsed and sinusoidal magnetic fields on the morphology of developing chick embryos. Bioelectromagnetics, 18: 431-438.

Fernie KJ, Bird DM, Dawson RD, Lague PC (2000). Effects of electromagnetic fields on the reproductive success of American kestrels. Physiol. Biochem. Zool., 73: 60–65.

Grigoriew JG (2003). Influence of the electromagnetic field of the mobile phones on chickens embryo, to the evaluation of the dangerousness after the criterion of this mortality. J. Radiat. Biol., 5: 541-544.

Hyland GJ (2000). Physics and biology of mobile telephony. Lancet, 356: 1-8.

Juutilainen J (1986). Effects of low frequency magnetic fields on chick embryos: Dependence on incubation temperature and storage of the eggs. Z. Naturforsch. A, 41c: 1111-1115.

Juutilainen J, Saali K (1986). Development of chick embryos in 1 Hz to 100 kHz magnetic fields. Radiat. Environ. Biophys., 25:135-140.

Juutilainen J, Harri M, Saali K, Lahtinen T (1986). Effect of 100-Hz magnetic fields with various waveforms on the development of chick embryos. Radiat. Environ. Biophys., 25:65-74.

Juutilainen J, Laara E, Saali K (1987). Relationship between field strength and abnormal development in chick embryos exposed to 50 Hz magnetic fields. Int. J. Radiat. Biol., 52: 787-793

Ketchen EE, Porter WE, Bolton NE (1987). The biological effects of magnetic fields on man. Am. Ind. Hyg. Assoc. J., 39: 1-11.

Koch WE, Koch BA (1991). Exposure of chicken embryos to selected magnetic fields. J. Bioelectricity, 10: 65–80.

Liboff AR, Jenrow KA (2000). New model for the avian magnetic compass. Bioelectromagnetics, 21: 555-565.

Liburdy RP, Callahan DE, Harland J, Dunham E, Sloma TR, Yaswen P (1993). Experimental evidence for 60 Hz magnetic fields operating through the signal transduction cascade: effects on calcium influx and c-MYC mRNA induction. FEBS Lett., 334: 301-308.

L'oscher W, K'as G (1998). Conspicuous behavioural abnormalities in a dairy cow herd near a tv and radio transmitting antenna. Prac. Vet. Surg., 29: 437-444.

Marks TA, Ratke CC, English WO (1995). Stray voltage and developmental, reproductive and other toxicol. problems in dogs, cats and cows: a discussion. Vet. Hum. Toxicol., 37: 163-172.

Meir M, Ar A, Nir A (1984). Preincubation dipping of turkey eggs. Does it affect eggshell conductance? Poult. Sci., 63: 2475-2478.

Meuer HJ, Baumann R (1988). Oxygen pressure in intra- and extra-embryonic blood vessels of early chick embryos. Resp. Physiol. 71:331-342.

Peebles ED, Brake J (1985). Relationship of eggshell porosity to stage of embryonic development in broiler breeders. Poult. Sci., 64: 2388-2391.

Phillips JL, Haggren W, Thomas WJ, Ishida-Jones T, Adey WR (1992). Magnetic field- induced changes in specific gene transcription. Biochim. Biophys. Acta., 112: 140-144 .

Pierra V, Rodriquez A, Cobos A, Torrente M, Cobos P (1992). Influence of continuos electromagnetic fields on the stage, weight and stature of chick embryo. Acta Anat. Base, 145: 302-306.

Rahn H, Ar A (1974). The avian egg: Incubation time and water loss. Condor, 76: 147-152.

Rahn H, Christensen VL, Eden FW (1981). Changes in egg conductance, pores, and physical dimensions of egg and shell during the first breeding cycle of turkey hens. Poult. Sci., 60: 2536-2541.

Romanoff AL (1930). Biochemistry and biophysics of the development hen's egg. Memoir. by Cornell University. Agricultural Experiment Station, 132: 1-27.

SAS Institute (1985). SAS User's Guide: Statistics (Cary, NC, SAS Institute Inc.).

Shafey TM, Al-Batshan HA, Al-Hassan MJ, Al-Haidary AA, Al-Faraj A, Ghannam, MM (2005a). Embryonic growth of chicks under the influence of electric field. Int. J. Poult. Sci., 11: 872-878.

Shafey TM, Al-Batshan HA, Ghannam MM (2007). Effects of electric field on hatchability performance of a layer-type breeder eggs. Br. Poult. Sci., 48: 145-153.

Shafey, TM, Al-Batshan, HA, Ghannam MM, Al-ayed MS (2005b). Effect of intensity of eggshell pigment and illuminated incubation on hatchability of brown eggs. Br. Poul. Sci., 46: 190-198

Shafey TM, Aljumaah RS, Swillam SA, Al-mufarrej, SI, Al-abdullatif AA, Ghannam MM (2011). Effects of short term exposure of eggs to magnetic field before incubation on hatchability and post-hatch performance of meat chickens. Saudi J. Biol. Sci., 18: 381-386.

Toman R, Jedlicka J, Broucek J (2002). The influence of a temporary magnetic field on chicken hatching. J. Environ. Sci. Health. A, 37: 969-974.

Ubeda AJ, Leal MA, Trillo MA, Jimenez MA, Delgado JMR (1983). Pulse shape of magnetic fields influences chick embryogenesis. J. Anat., 137: 513-536.

Ubeda A, Trillo MA, Chacon L, Blanco MJ, Leal J (1994). Chick embryo development can be irreversibly altered by early exposure to weak extremely-low-frequency magnetic fields. Bioelectromagnetics, 15: 385-398.

Veicsteinas A, Bellerii M, Cinquetti A, Parlini S, Barbato G, Molinari Tosatti MP (1996). Development of chicken embryos exposed to an intermittent horizontal sinusoidal 50 Hz magnetic field.

Bioelectromagnetics, 17: 411-424.
Youbicier-Simo, BJ, Bastide M (1999). Pathological effects induced by embryonic and postnatal exposure to EMFs radiation by cellular mobile phones. Radiat. Prot., 1: 218-223.