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EFFECT OF MAGNETIC WATER ON SOME ACTIVITIES OF HONEY BEES (Apis mellifera L.) in Jazan Province KSA

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ABSTRACT

Background: Magnetic water has a potential role in the enhancement of vital activities at the cellular level including immunity, and several biological activities. **Aim**: This study aimed to evaluate the potential effect of magnetic water on sealed workers' brood, the average body, head weight, average head diameter, as well as, the average Acini number and canal diameter of the hypopharyngeal gland of the honey bee workers (*Apis mellifera L.*) in Jazan province in KSA. **Material** &**methods**: The experiments were performed and replicated three times on honey bees (three cages for each group). The first group was preserved as a control (feeds on sugar syrup), while the second group was supplemented with magnetized water in addition to sugar syrup. Each cage was settled with 100 worker bees collected from mountain combs. **Results**: The obtained results showed that the sealed worker's brood colonies (square inches) treated with magnetic water increased significantly compared with the control. Also, the average body weights of workers and drones were significantly increased compared with their control. Furthermore, the average head weight of workers has appeared with non-significant change if compared with control, while for drones was significantly increased. Regarding the effect of magnetized water on the head diameter, it was found that the effect of magnetized water on the head diameter (width and length in mm) was non-significant compared with the control. Moreover, the means of acini number of hypopharyngeal glands in 12 days-old workers bees fed on magnetized water was increased slightly. Also, the canal diameter of the hypopharyngeal gland appeared slightly higher than the control. **Conclusion**: It was concluded that magnetic water has potency in some parameters of the honey bee workers.

Keywords: Magnetic water, honey bee, drones, hypopharyngeal gland.

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INTRODUCTION

The honey bee is a very important insect for both the economy and the environment. Along with a variety of non-food items including beeswax and royal jelly, it is a well-known producer of food. As natural cosmetics and snacks, these products are particularly well-liked. One of the most significant pollinators is the honey bee, alongside these. Honeybees require minerals, proteins, and carbohydrates for growth, development, and reproduction, much like any other living thing. After nectar, pollen is the second food source. It has the necessary nutrients for the head glands to make the growth hormones required for larval growth, and it is rich in proteins, vitamins, and fats to complete the life cycle (***Younis, 2011***).

Magnetic water means passing water or its solutions through the magnetic field (***Raafat, 2013***). The body's cells and tissues can absorb magnetic water, which has the power to considerably dissolve nutrients and enhance nutrient absorption. This enables the digestion of these tissues with nutrients more quickly than with ordinary water (***Kronenberg, 1986)***. Additionally, water solutions that have been subjected to magnetic fields develop finer and more uniform structures, which improve fluidity and the capacity of minerals and vitamins to dissolve in the water, thus improving animal performance (***Al-Mufarrej et al 2005; Khudiar and Ali 2012***).

The production of more hydroxyl (OH^-) ions under the influence of magnetic fields results in the formation of more alkaline molecules, which raises the dielectric constant and electric conductivity of water (***Ibrahim, 2006; Khudiar and Ali 2012***; ***Yacout et al 2015***). Normal water has a PH level of about 7, whereas magnetized water can reach a PH of 9.2 following exposure to 7000 gausses for a long period of time (***Khudiar and Ali, 2012).***

According to a study done on rats, the pancreatic exocrine and endocrine systems can be shielded against the adverse effects of type 2 diabetes by the use of magnetic water (***Saleh et al 2018***). According to ***Higa (2004),*** a magnetic field gives water molecules a remarkable capacity to avoid oxidation, enhancing the benefits of water for health and boosting the body's resistance. **Taber (1986)** explained that feeding honey bee colonies with a magnetized sugar solution in early spring stimulated queens to lay eggs early, which led to increasing the brood area. **Tyari et al. (2014)** added that providing bees with magnetized water led to a much higher proportion of female workers and honey collectors, as well as higher yields of honey**.** It had been reported that feeding colonies with non-magnetized water showed an increase in brood by 11% while colonies that fed with magnetized water led to increase the brood by 16% (**Shoreit and Hussein (1993)**. Additionally, it has been discovered that providing magnetized food to bees promotes the colony to continually gather pollen and raise brood (**Dreller *et al*. (1999)**. Accordingly, the current work was mainly designed to discriminate the ameliorative effect of magnetized water on the activities of workers and drones of honey bee hives.

MATERIALS AND METHODS

1. Experimental design

The experiment was performed in April 2022 at the apiary of Jazan University, KSA. It was replicated three times (in three cages). Each cage was settled with 100 worker bees collected from mountain combs. Bees were fed sugar syrup at 3:2 concentrations (3 parts of sugar and 2 parts of water) with an addition of 5% standardized water plant extracts. Cages were kept in an incubator at 25ºC. Every day the number of larvae and syrup consumption was recorded. After 12 and 18 days bees were killed by freezing for analysis.

Bees were divided into two groups: the control group (G_1) and the magnetic-treated water group (G_2). G_1 was fed sugar syrup at 3:2 concentrations and allowed free access to water. G_2 fed sugar syrup at 3:2 concentrations and received magnetically treated water at magnetic strength 600 G. Subsequently, the bees were weighed, measured their dimensions, and

dissected to examine their hypopharyngeal glands. The degree of hypopharyngeal gland development was scored using a scale to determine acini number and canal diameter. The samples were viewed using a binocular microscope at 100x magnification. A fragment of the dissected hypopharyngeal gland was placed on a slide in a drop of water. Each series also involved examinations of non-caged bees collected directly from the hive on the day experiments had started (control).

2. Preparation of magnetic water

The magnetic water was prepared by passing drinking water through a hand-made electro-magnet unit (***Ahmed Saleh et al 2018***). Two coils connected in series are experiencing a DC current that is regulated by a transistor. The magnetic field intensity was controlled via a potentiometer. A water pump that was built inside the appliance pumped water through a flexible tube. The magnetic coils were spaced apart by roughly 15 mm. The created magnetic field had a 600 G magnetic field strength (as measured by a WT10A Tesla meter), was uniform, and was parallel to the water flow. Water flow was at a relatively low speed (0.34 L/min) to avoid overflow. The 600G is an average strength that has been tested to cause no pathological lesions in experimental rats (***Al-Saffar SF. et al 2013***).

3. Glands dissection and acini measurements

Workers were arrested with CO_2 and the head in Hyes' solution (NaCl 9.0 g, KCl 0.2 g, CaCl 0.2 g, NaHCO3 0.1 g, 1 l purified water, pH 8.5) was fixed with two entomological needles on elastic base (Xantopren® L blue and general Activator, Heraeus Kulzer, Germany) in a Dish of Petri. Dissection was performed using a stereomicroscope (SterREO Discovery.V12, Zeiss). Behind the compound eyes, the external chitinous exoskeleton of the facial area of the head was extracted and prepared for a further histological procedure.

The gland lobes (acini) of nursing workers in winter bees have been studied morphologically in vivo using a stereomicroscope (SterREO Discovery.V12, Zeiss) and camera (Zeiss). The AxioVision Rel software 4.6 was used to process the photos and measure them subsequently. For three employees of the same age, the diameters of 30 randomly selected acini were measured perpendicular to the longer axis of the oval acinus. An acinus has an oval shape, however, only the shorter axis length has been calculated and used as a measurement.

Data analysis

Data were statistically evaluated with SPSS 13.0 (SPSS Inc.; Chicago, IL, USA). The Means and Descriptive basic statistical parameters were determined. Significant variations in the diameter of the acini were measured using one-way ANOVA, with a filter as an introduction to the cell bar (1 to 3) and colony type (worker colony and control colony). Comparison of the data of different aged employees. The mean acini diameter of HPGs was compared between workers from the nurse colony and the control colony, using One-way ANOVA with age as a factor and further compared with cell bar starter as a factor. Scheffe's test was used for data testing. The Acini diameter in the HPG was measured for pupae and winter bees. The Means and Descriptive basic statistical parameters were determined. The significance of differences was measured at $p \leq 0.05$.

RESULTS

1. Efficacy of magnetized water on sealed workers' brood

The magnetized water was produced by exposing the relatively low-speed water flow to 600G magnetic strength. The obtained result revealed a marked significant increase in the sealed worker's brood (192±5.3 square inches) reared by the magnetized water group compared to the control group(174 square inches) (Table 1).

Table (1). The effect of magnetic water on sealed worker's brood (square inches) of *Apis mellifera L*

	Groups			
	Control, G_1	Treated, G_2		
Number of sealed workers	174	193	185	198
		Average		
		192±5.3		

The data in the table shows that sealed workers' brood (square inches) for magnetic-treated water colonies of *Apis mellifera L* increased significantly (p-value 0.001) compared with the control. The result is significant at P<0.05.

2. Effect of magnetic water on the average body weight, head weight, and average head diameter

In the magnetized water-reared group for consecutive 18 days, the average body weight of workers and drones was significantly increased (for workers P value = 0.045 while for drones P value = 0.08) compared with the control group (Table 2). Furthermore, the average head weight of workers (Table 3) showed non-significant compared with control (P value =0.28), while for drones was significantly increased (P value = 0.048). Regarding the effect of magnetized water on the head diameter (Table 4), it was found that the effect of magnetized water on the head diameter (width and length) appeared with non-significant compared to the control (for width (mm), P value = 0.299 and for length (mm), P value = 0.329).

It was observed that the head diameter of the honey bee workers reared on magnetized water at the tested ages (18 days) increased gradually till reach its maximum value at 18-days old drones, then it decreased sharply. We found that magnetized water leads to a non-significant change in head length and width of treated workers (3.12 and 2.5) respectively when compared with untreated groups.

Table (2). The effect of magnetic water on body weight (mg) of honey bee workers (Apis mellifera L)

Species	Test	Groups			
		Control, G_1	Treated, G_2		
Workers	Body weight 18 days old (mg)	108.67	166	135.05	147.3
			Average		
			149.45		
Drones		119.56	173.16	148.66	137.06
			Average		
			164.96		

Average body weight of honey bees fed on sugar syrup with the addition of magnetic water (mg). For the worker's body weight, the P value = 0.045 while for the drone's body weight P value = 0.08. The result is significant at P<0.05

Table (3).The effect of magnetic water on head weight (mg) of Drones of honey bee (Apis mellifera L)

Species	Test	Groups			
Workers	Head weight 18 days old (mg)	Control, G_1	Treated, G_2		
		13.8	17.37	10.35	18.50
			Average		
			15.41		
Drones		12.39	19.97	12.84	18.22
			Average		
			17.01		

Average head weight of honey bees fed on sugar syrup with the addition of magnetic water. For the worker's head weight, P value = 0.28 the results are non-significant. For the drone's head weight P value = 0.048, the result is significant. The result is significant at $P<0.05$

Table (4). The effect of magnetic water on head diameter (mm) of 18-day-old workers of honey bee (Apis mellifera L)

Species	Test		Groups			
Workers	Head diameter 18 days old	Width (mm)	Control, G_1	Treated, G_2		
			2.24	3.16	2.74	1.61
				Mean		
				2.5 ± 0.8		
		Length (mm)	3.38	3.84	3.47	2.05
				Mean		
				3.12± 0.94		

Average head diameter of worker bees (18 days old) fed on sugar syrup with the addition of magnetized water. For width (mm), P value = 0.299 (non-significant), and for length (mm), P value = 0.329 (non-significant). The result is significant at $P<0.05$

3. Potency magnetized water on the average acini number

As shown in table (5) and figure (1), the recorded means of acini number of hypopharyngeal glands in 12 days-old workers bees fed on sugar syrup with the addition of magnetized water was slightly increased (P value = 0.144). Also showed that, a slightly increased in the canal diameter (P value = 0.093).

For 18 days old (Table 6 and Fig. 2), the recorded means of acini number of the hypopharyngeal gland of workers bees fed on sugar syrup with the addition of magnetized water was slightly increased non-significant (Figs.1&2) (P value = 0.10). Also showed that, a slightly increased in the canal diameter (P value = 0.17).

Table (5). The effect of magnetic water on acini number and canal diameter (µm) of Hypopharyngeal of 12 days old workers of honey bee (*Apis mellifera L*)

Species	Test		Groups			
Workers	Hypopharyngeal glands (12 days)	Acini No.	Control, G_1	Treated, G_2		
			545	531	583	675
				Mean		
				596.33± 5.96		
		Canal diameter (µm)	24.4	23.6	29.57	29.37
				Mean		
				27.5		

Acini number and canal diameter **(µm)** of Hypopharyngeal glands of honey bees fed on sugar syrup with the addition of magnetized water (12 days old). P value = 0.144 (non-significant). For the canal diameter P value = 0.093 (non-significant). The result is significant at P<0.05

Table (6). The effect of magnetic water on Acini number and canal diameter (µm) of Hypopharyngeal of 18 days old workers of honey bee (*Apis mellifera L*)

Species	Test		Groups			
Workers	Hypopharyngeal glands (18 days)	Acini No.	Control, G_1	Treated, G_2		
			674	686	709	828
				Mean		
				741± 7.4		
		Canal diameter (µm)	26.19	29.48	27.14	25.57
				Mean		
				27.40		

Acini number and canal diameter **(µm)** of hypopharyngeal glands of honey bees fed on sugar syrup with the addition of magnetized water (18 days old). P value = 0.10 (non-significant). For the canal diameter P value = 0.17 (non-significant). The result is significant at P<0.05

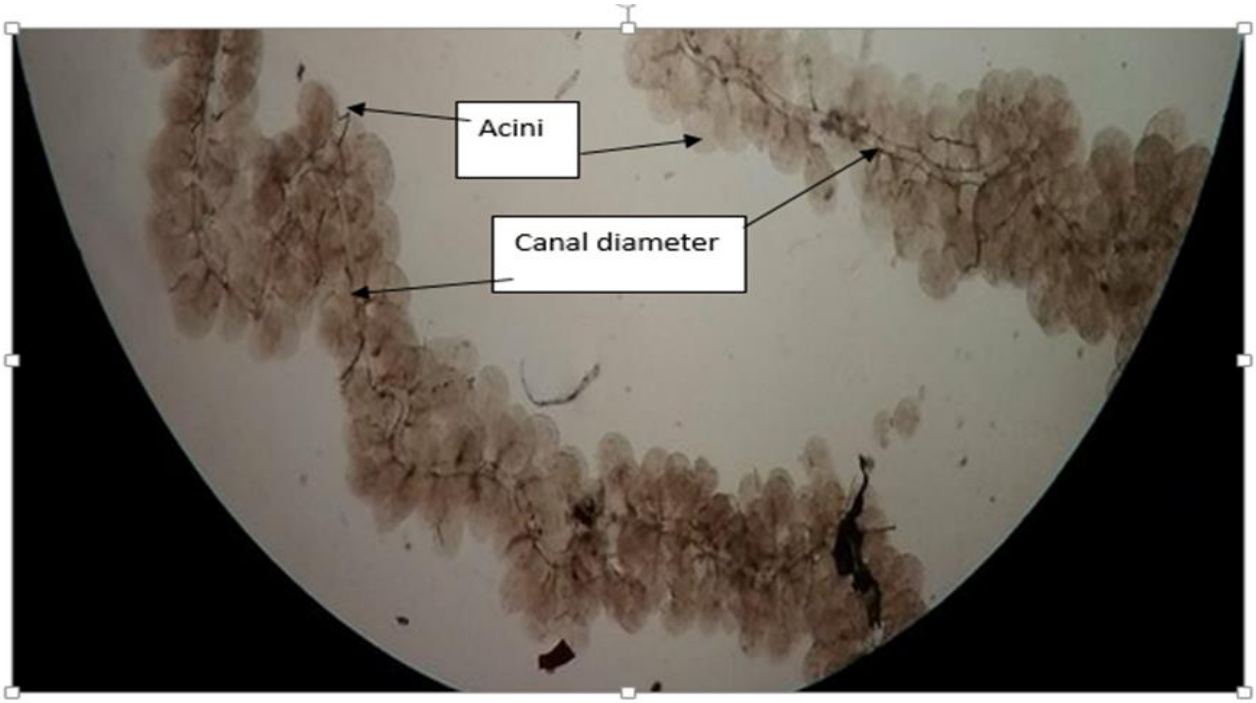

Fig.1: Hypopharyngeal gland of Honey bee worker (18 days old) fed on sugar syrup (control)

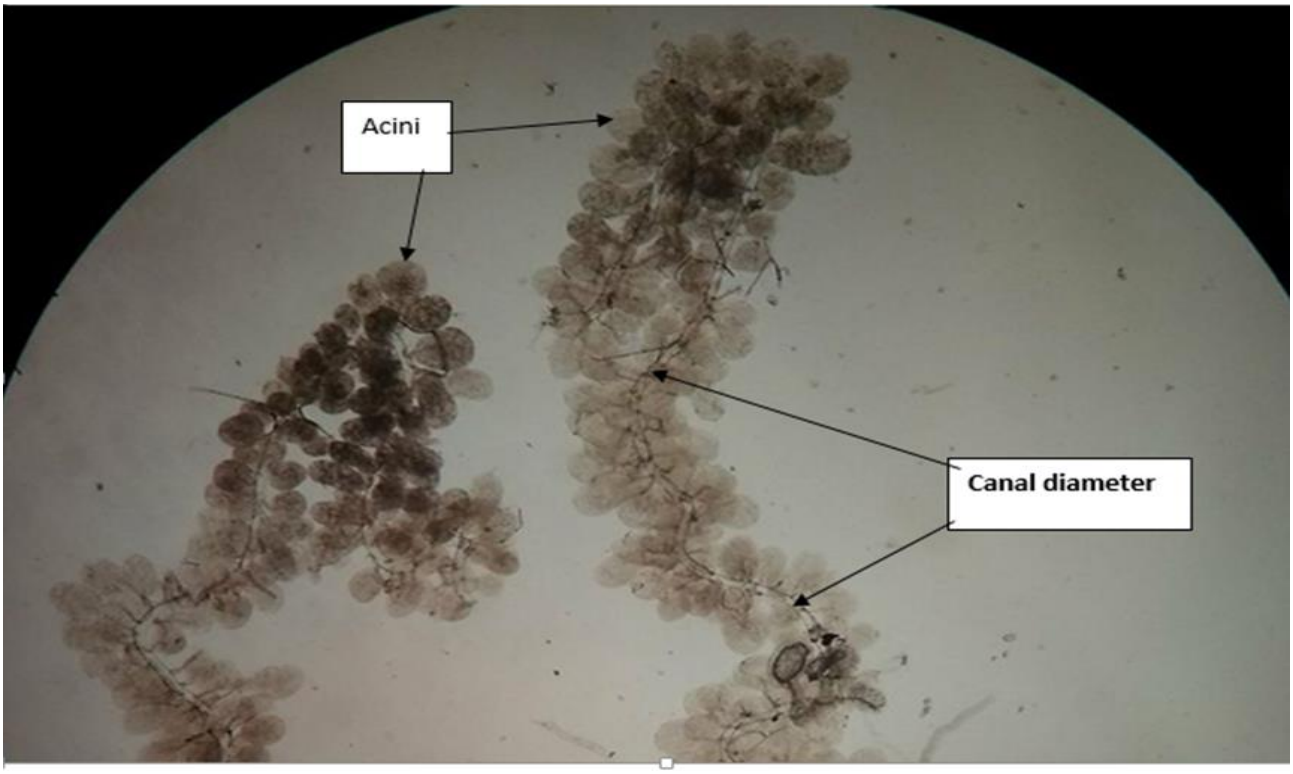

Fig.2 Hypopharyngeal gland of Honey bee worker (18 days old) reared on magnetized water. The number of acini and diameter of hypopharyngeal canals appear significantly higher than the control (Contrio in Fig.1)

DISCUSSION

In this study, we investigated the expected effects of the magnetically treated water in the amelioration of some parameters of honey bee workers (*Apis mellifera* L.) in Jazan province in KSA. Our results verified the efficacy of magnetized water on increasing sealed workers' brood and showed that sealed workers' brood (square inches) for magnetic-treated water colonies of *Apis mellifera L* increased significantly. Coinciding with our findings, ***Shoreit and Hussein (1993)***, reported that feeding colonies with non-magnetized water showed an increase in brood by 11% while those fed with magnetized water led to an increase in the brood by 16%. Also, the above results are supported by ***Mahrous (1962)*** who observed that the use of pollen supplements increased the colony population. ***Brar et al. (1992)*** found that the colonies continued brood rearing throughout the year with the major peak occurring during March-May at all the locations. A second peak, though of low magnitude, also occurred during November. ***Mishref et al. (1995)***, ***El-Shaarawi (2001), El-Waseef (2002), Kalev et al***. ***(2002)***, *and* ***Serag El-Dien*** *And* ***Eissa (2003)*** whose studies indicated that the honeybee colonies provided with pollen substitutes reared more worker brood than in case of unfed ones (Control colonies) during the observation period.

We observed that the average body weight of workers and drones was significantly increased (for workers P value = 0.045 while for drones P value = 0.08) compared with the control group Furthermore, the average head weight of both workers was non-significant compared with control (P value =0.28), while for drones was significantly increased (P value = 0.048). Regarding the effect of magnetized water on the head diameter (table 4), it was found that the effect of magnetized water on the head diameter (width and length) was non-significant compared with the control group (For width (mm), P value = 0.299 and for length (mm), P value = 0.329). It was observed that the body weight of the drones and workers at the tested ages the average body weight of workers and drones reared by magnetized water was significantly increased compared with the control group. Furthermore, the average head weight of workers was non-significant compared with control while for drones was significantly increased. (Regarding the effect of magnetized water on the head diameter it was found that the effect of magnetized water on the head diameter (width and length) was non-significant compared with the control group. In this respect, ***Hegazy (1974)*** found that the weight of the *Carniolan* drone was highly significantly heavier than that of the Egyptian one at the same age. The highest weight was recorded in drones of both races collected soon after emergence. Then the weight decreased by age, to reach the minimum 18 days after emergence. The kind of diet offered to drones greatly affected their weight. The highest weight was recorded when drones were fed on royal jelly. The minimum was however given when reared on pollen grains.

The protein-rich worker bee and royal jelly, which are fed to growing larvae and queens, are made by honeybees in their hypopharyngeal glands. The quantity and caliber of the honeybee's food intake is very sensitively regulated by these paired glands, which are found in the bee's head. Bees fed incomplete meals have smaller glands, while bees fed complete diets have larger glands. The hypopharyngeal gland's size is a reliable predictor of the diet of bees because of that ***(Vanessa Corby-Harris and Lucy A. Snyder 2018).***

In this concern HPGs start to develop in worker pupae about a week before emergence and continue after bees emerge from the brood comb, changing their structure until they die. In this research, we test the ability of glands to elongate their activity and increase their size and number which depend on the

age of the quality of food. The HG secretion is the main component of royal jelly, a material rich in protein and other nutrients that feed young larvae, contributes to caste differentiation because of its morphogenetic properties, and is also the queen's exclusive source of nutrients. ***(Michener 2007; Kamakura 2011).*** In The present study, results demonstrated that the recorded means of acini number of hypopharyngeal glands in 12 days-old workers bees fed on sugar syrup with the addition of magnetized water was slightly increased.

Also showed that a slightly increased in the canal diameter agree with ***DeGrandiHoffman et al. (2010)*** who said that the finest results were detected for the group fed on treatment T3 (honey + pollen). Protein availability affected the size of acini, as groups of honeybees fed with protein enhancements offered acini with greater areas as matched with groups that were fed wholly with pollen and honey.

At the same time there the recorded means of acini number of the hypopharyngeal gland of 18 days old workers bees fed on sugar syrup with the addition of magnetized water was slightly increased. Also showed that, a slightly increased in the canal diameter of the same workers when compared with workers' bees fed on sucrose only. These findings were not in same line with the result obtained by ***Al-Ghamdi et al. (2011)*** When evaluating food protein concentration and development of HG in Carniolan bees, verified a better development although other groups of the same category of bees were fed with rations with higher protein content and provided with underdeveloped glands, the structure of those fed with apicultural pollen also found that the consumption of diets based on soybean extract, milk powder and brewer's yeast was 56.63 percent lower than the consumption of diets based on apicultural pollen. Therefore the development of diets including fractions of apicultural pollen in their composition may be a good solution to minimize dietary aversion and increase nutrient absorption, resulting in better overall hive development and improved royal jelly production.

As is clear from the previous data in this study we found that the recorded means of acini number of the hypopharyngeal gland of workers bees fed on sugar syrup with the addition of magnetized water was slightly increased. Also showed that, a slightly increased in the canal diameter. this agrees with the result data obtained by ***Zahra and Talal (2008)*** observed that the effect of supplemental feeding in hives of *A. mellifera* an increase in mean acinus size and HG ducts length was promoted with high values obtained in hive supplemented with vitamin C, overcoming soybean-based supplements extracts.

Conclusion

In the current study, we investigated the expected effects of the magnetically treated water in the amelioration of some parameters of honey bee workers (*Apis mellifera* L.) in Jazan province in KSA. Our results verified the efficacy of magnetized water in increasing sealed workers' brood

Also, it was reported that the recorded means of acini number of hypopharyngeal glands in 12 days-old workers bees fed on sugar syrup with the addition of magnetized water was slightly increased. Also showed that, a slightly increased in the canal diameter. The recorded means of acini number of the hypopharyngeal gland of workers bees fed on sugar syrup with the addition of magnetized water was slightly increased. Also showed that, a slightly increased in the canal diameter.

Conflict of interest

All authors declared that there were no conflicts of interest.

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