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Mini Review

The effect of magnetic water in biological performance of honey bee colonies *Apis mellifera* L. (hymenoptera: apidae) - A mini review

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ABSTRACT:

Magnetized water is obtained by passing through or nearer to a specific magnetic field for a period of time. The benefit of this process is that it works to re-activate and improve many of its lost properties, including electrical conductivity and increase in the concentration of oxygen dissolved in water and increasing the ability to dissolved salts, acids polymerization, surface tension, change in the speed of chemical reactions, evaporation, wetness, softness, optical properties, electrical insulation, and increased permeability to become more energy and speedy than without magnetic treatment. The magnetization process re-organizes the water charges correctly while the shape of these charge is random and irregular in non-magnetized water. This magnetic field also works to reduce the viscosity of water because it increases the liquidity of water and makes it magnetized by magnetic properties through its ability to dissolve various components such as minerals and vitamins. It retains magnetic qualities up to 200 h. Magnetized water plays an important role in the biological performance of honey bees and that Honey bee colonies treated with magnetized water have improved as they reduce their agitation and increase their activity in the collection of honey as well as their daily needs of water, brood breeding storage of honey and pollen increase in their ability to produce royal food and secretion of wax in the collection of nectar, pollen and propolis as well as increased amounts of Bio-iron granules beneficial to the human body in honey bees. The effect of feeding the dissolved sucrose with magnetized water led to an increase in the area of brood, honey and pollen, and increased the rate of weight of wax frames and an increase in the number of workers, the number of frames occupied by workers and increased food stocks of honey and pollen.

Keywords:
Magnetic water, Honey bees, *Apis mellifera L.*

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INTRODUCTION

Honey bees *Apis mellifera* L. is an important social insect and raised at the top of the scale of these insects in terms of economic importance and members of its colonies can not live alone. Its members are connected to each other according to a strict social system, and each of its members know it's duties accurately. Bee colonies are active throughout the year despite the different climatic conditions and temperature variations, and this activity has become a close and strong link with the humans. It has become an important element in its economic field where plant production and increased yields were associated with bees in addition to the honey production from important materials. It is of great interest to humans and conducted a lot of research that included all aspect of bees and this research developed through the use of modern techniques to understand the secret of its biological behaviour (Pimentel *et al*., 1997). Bees are one of the most efficient pollinators, accounting for 80% of pollinated insects of cultivated crops because of their total dependence on feeding the plant flower products and the ease of raising them in large numbers in hives that can be transferred from one region to another and of great importance in increasing plant production (Delaplane and Mayer, 2000).

Honeybees, like any living organism, need carbohydrates that provide the insect's body with energy, proteins and minerals for its growth, development and reproduction. These are collected during the collection of nectar, pollen and water. The group consumes some of them to sustain their various activities and store more of their needs in the hexagonal eyes to benefit from them at the time of need (Al-Zubaidi, 1998). Pollen is the second nutritional source after nectar and is important for the growth of honeybee phases because it contains proteins, vitamins and fats to complete the life cycle, and it provides the essential nutrients of the head glands to produce growth hormones necessary for the growth of larvae (Younis, 2011).

Supplying honey bee colonies with supportive foods like pollen and nectar supplements or supplements maintain the strength and activity of colonies and provides them with food and improves their performance better (Farrar, 1993). Shaher and Jorany (2010) reported that the area of brood and the power of the colony are directly proportional to the amount of pollen collected by bees and that the hive lacking pollen completely stops producing brood. Magnetically treated water is one of the most important principles of magnetic therapy, because water plays a pivotal role in regulating and activating all vital processes that occur within the body that positively affect the productive performance of animals and plant growth (Goldsworthy *et al*., 1999). The passage of water or its solutions through the magnetic field makes it more homogeneous (Raafat, 2013). The magnetic water treatment technology is scientific and so, used in many countries of the world and is considered by some scientists a unique recipe that achieving many benefits by raising the ability of the immune system and accelerate the growth of animals and plants as water absorbs magnetic resonance when passing through a magnetic field, thus gaining exceptional ability to prevent oxidation and thereby increase the body's immune capacity and improve the health benefits of water (Higa, 2004).

The treatment of honey bees with magnetized water directly leads to the dissolution of nutrients significantly and the possibility of absorption by the cells and tissues of bees body where many of its behavior changes, including increasing the activity of domestic workers in the production of wax and building wax frames in short time compared to the non-treated colonies. The process of magnetization is also used to increase the activity of the workers in organizing and directing their work within the hive. Al-Kinani and Qassem (2012) reported that the treatment of magnetized food outweighed the natural feeding treatment, giving an incubation area of 2739.24 cm^2/colon, while the incubation

area was 1494.36 cm^2 / colony at the estimated magnetic nutrition. Tyari *et al*. (2014) noted that giving magnetized water to bees by placing it directly in the hives or by placing it in the food provided to the bees or by the bee-fed plants led to a significant increase in the number of female workers and honey collectors, as well as increased amounts of honey produced. More than 25% were of high quality in terms of changing taste, colour and smell compared to ordinary honey as well as high therapeutic properties. Due to the lack of articles on the use of magnetized water in bee feeding and its impact on the biological performance of honey bees, this article aimed to collect studies on magnetic water and its importance to honey bees.

The importance of nutrition in biology of honey bees

All organisms, including bees, need proteins, carbohydrates, fats, vitamins, mineral salts and water to grow and develop. If lack of food in the bee colonies may lead to disruption in the stages of growth of these individuals or perhaps to death must be compensated to preserve the life of colonies (Al-Dorkzali, 1982). A number of researchers have been interested in feeding bees when evaluating the effect of nutrition, substitutes and supplements of honey and pollen on the activity of honey bees by studying its effect on measuring brood area, density of honey, honey productivity and the amount of pollen stored as food for energy. From three natural sources: nectar, pollen and water and the use of these substances are also important not only in the development and growth of colonies during the spring, but during other stages of the year (Seeley, 1985).

Feeding honey bee colonies with carbohydrate sources

Carbohydrates are the main source of energy needed by the animal's body, including honeybees. Honey is the best source of carbohydrates to feed the honeybee colonies as it contains sugar glucose, fructose and sucrose in addition to other sugars present in its composition, and complex forms of these carbohydrates require some physiological processes to release energy in its useful form (liberation of ATP) but honey bees by turning nectar into honey and then consumption of honey rich in sugars induce rapid conversion to ATP makes it easier for the body's metabolic system to take advantage of the sugar components of the nectar. The amount of honey needed by the colony in its diet encompasses several factors such as the strength of the colony and its activity in brood rearing and the quality of the nectar available, and in order to continue its activity during the year, it needs about 60 kg of honey and 25 - 50 kg of pollen (Southwick, 1992).

Herbert (1992) reported that honey bees obtain carbohydrate sources from plant nectar, which consists of an aqueous solution of a number of sugars (glucose, fructose, sucrose), vitamins, minerals, acids, enzymes and some aromatic substances, as well as other secondary sources. The secretions of some of the insects of Homoptera are called honeycomb and fruit juices. Although most sugars in the nectar range between 25 and 40%, the sugars in general in the nectar of plants may range from 5 to 75%. Shuell (1993) noted that the amount of nectar from flowers are influenced by many factors, external and internal and workers rarely collect nectar with a concentration of less than 5%. The higher the proportion of sugars in the nectar, the more attracted workers to them, but in the seasons of nectar, scarcity in nature beekeepers provide sugar solutions to make up for the shortage and to help workers to continue their daily life functions. Sucrose, glucose and fructose are often used in artificial bee feeding.

White (1993) stated that honey bees, like any living organism, need carbohydrates, proteins, minerals and water to grow, develop and reproduce and obtain them from collecting water, nectar and pollen, the colony consumes some of what it collects to sustain its various activities and store more than it needs in the hexagonal eyes to benefit from it in time of need. Stored quantities of nectar and pollen have to do with the pow-

er of the colony, the ability of the queen to lay eggs, brood area and regularity, and the total honey area, which mainly controls the area in which the bee colonies are raised and their environmental conditions, The colony also gets its carbohydrate requirements from floral nectar (Zahra and Talal, 2008). Al-Fishawi (2009) explained that the workers are collecting nectar, which is about 20% sugar and to convert the nectar rich in bilateral sugars to honey mechanically treated by evaporation of moisture from it and enzymatically converting sugars into two reduced sugars, glucose and fructose.

The concentrations of the types of sugar used in supplying bees to the source of energy vary according to the seasons of the year and the quantity required for each group and the need for recurrence of feeding depends on the density of members of the colony and the season. Gemeda (2014) in this area stated that feeding with sugary solutions is one of the most and best alternatives used in nutrition when the bee food is less than honey. This method depends on several factors, including the number of colonies in the apiary, the strength of the colony, the feeding time, and the location of the colony.

Feed colonies of honey bees with protein sources

The pollen in the hive plays a vital role in increasing the productivity of honey bee colonies as it is the main source to meet the nutritional needs of protein materials, mineral salts, vitamins and fats needed to build and compensate for lost body cells. There is a positive relationship between nutrition and brood area (Omar *et al*., 1992). Farrar (1993) pointed out that the strength and activity of honeybee colonies can be maintained and prevented from starvation and improve their performance better by supplying them with supportive foods with pollen substitutes or supplements and thus the development of royal pharyngeal glands and increasing the power of colonies to resist viral diseases. Preferably, these alternatives are palatable to bees and contain all the basic requirements for bees. In the absence of stored pollen, brood rearing cannot be maintained.

Neupane and Thapa (2005) noted that during the year there are phases of droughts in which there are no or fewer bee surfaces, and the colony consumes its food stocks. Dietary supplements and their use as industrial feeds are given to colonies to enable them to survive during the winter and summer, until the arrival of honey and nectar. Studies have shown that some protein sources have used pollen substitutes and supplements that have played an important role in activating colonies and maintaining their power. Nabors (2000) and Abdulla (2005) explained that there are three types of protein feeding, the first being called pollen substitutes while the second is called a supplement to pollen and the third is only natural pollen, and alternatives differ from supplements in that they do not contain pollen. There are a number of alternatives and supplements that can be offered to bees and that pollen supplements are materials mixed with pollen to increase the amount eaten by bees transported and benefited for growth and development, such as soybean flour mixed with pollen, while pollen alternatives in any food used entirely instead of pollen.

Brodschneider and Crailsheim (2010) reported that bee sects collect large amounts of pollen per year ranging from 25 to 50 kg per colony. A larval worker bee needs 1.52 to 2.04 mg pollen during larval growth, Bee workers consume 3.4 to 4.3 milligram pollen per day. And then the consumption of the workers of pollen gradually decreases until it stops at the age of 14 days to become the main food honey. Ellen (2014) explained that the absence or lack of pollen leads to stunted growth, reduced bee age and incomplete development of royal food glands leading to insufficient royal food production to support natural growth, larval development and egg production by queens, and thus a lack of brood rearing and honey production. The lack of proteins also affects the health of bees and the ability of bees to resist

diseases and weakened the immune system of bees, in some cases it may lead to famine and famine is probably the single most important cause of the death of honey-bee colonies.

The importance of water in biological of honey bees

Honey bees collect water intensively, especially in times of high temperatures, except for winter days. The worker needs water at the end of winter and early spring to use it to dilute the honey stored in the colony, which is used for brood food instead of concentrated honey, and that more than 50 gallons of water were taken from a solution of 50 colony during a week (Farrar, 1993; Essa and El-Kholy, 1994). Bees seem to have a certain preference for some sources of water than others and although there is no evidence that bees drink water under field conditions, but exposing bees to stress such as high temperature under working conditions with the availability of a water source forces bees to drink water to alleviate the stress. Bees receive their nectar water requirements, which contain approximately 60% water (Nicolson, 2009).

Al-Atbi (2013) explained that honey bees do not collect minerals directly but collect what they need indirectly by feeding them on pollen, nectar or drinking water, pollen is often rich in mineral elements ranging from 2.9 to 8.3%, there are approximately 27 rare mineral elements in pollen, including potassium, calcium, copper, iron and phosphorus ,the importance of the mineral elements of honey bees, as they play an important role in regulating the pressure of the osmotic fluid inside and outside the cells as well as working to maintain the ion balance appropriate for the activity of living cells.

Steen (2015) stated that the daily and annual consumption of honey bee colony is not known for accuracy, but was calculated at 25 liters/colony during brood rearing, and water has a significant role in tempering the atmosphere by evaporation cooling mechanism, which is necessary for honey bees because solvent for salts and organic components and is necessary for the representation in the cells of the body. Abou-Shaara (2014) pointed out that bees collect large amounts of water to provide optimal humidity for colonies which must not be less than 75% so that the bee eggs can hatch without deformations and for the brood to evolve naturally, as well as bees may collect water to relieve honey stock high viscosity or to drink or to reduce the sugary nutrition provided to him so that he can feed on them, and regulate moisture within inside the colony.

Magnetized water

Magnetically treated water is characterized by its ability to dissolve nutrients significantly and can be absorbed by the cells and tissues of the body, which leads to increased absorption of nutrients, which facilitates the processing of these tissues with nutrients faster than ordinary water (Kronenberg, 1986; Lin, 1990). Nagy (2005) showed that magnetically treated water is saturated with oxygen whereas magnetic fields can increase the rate of dissolution of oxygen and observed an increase in the concentration of dissolved oxygen in water above the normal level. Sueda *et al*. (2007) and Toledo *et al*. (2008) reported that the process of water magnetization is accompanied by a combination of changes in the physical and chemical properties of water, including increased dissolved oxygen concentration, reduced surface tension, increased solubility of solids, increased electrical conductivity, nutrient readiness and improved cell membrane permeability as well as low viscosity compared to normal water.

Ahmed (2009) noted that water molecules are moving in one direction after water passes through a magnetic field with a certain flux density. This directed arrangement causes the hydrogen bond to be withdrawn and broken and aligns water molecules in a certain direction as it passes through the magnetic field and reduces the bonding angle to less than 104.5°, which reduces the level of union between molecules, on the other hand, decreases in particle sizes due to the breakage

of hydrogen bonds.

How honey bees get magnetized water?

Frier *et al*. (1996) reported that the treatment of honeybee colonies with magnetized water has changed many of their behaviour, including increased activity of domestic workers in the production of wax and building wax frames in short time compared to the untreated colonies. The process of magnetization also increases the activity of the worker bees in organizing and directing their work within the colonies. Amiri and Dakhah (2006) and Toledo *et al*. (2008) have shown that magnetically treated water is characterized by low viscosity, high basal (pH), increased dissolved oxygen, reduced surface tension, increased solids and improved permeability through the membrane of the honeybees body and the readiness of soluble elements such as sugars, proteins and acids, the amino is absorbed faster by the honeycomb body cells. Magnetically treated water is characterized by its ability to dissolve nutrients significantly, and the possibility of absorption faster and better by the cells and tissues of the body of honey bees, which leads to increased absorption of nutrients, that facilitates its permeability to cell membranes, which results in increased absorption of nutrients quickly compared to normal water (Lin, 1990; McMahon, 2009).

Effect of magnetized water in the life performance of honey bees

Effect of feeding on brood area

Taber (1986) explained that feeding honey bee colonies with a magnetized sugar solution in early spring stimulated queens to lay eggs early, than led to increasing the brood area. Shoreit and Hussein (1993) reported that feeding colonies with non-magnetized water showed an increase in brood by 11% while the were fed with magnetized water led to increase the brood by 16%. Frier *et al*. (1996) reported that the treatment of honey bee colonies by direct magnetization led to many changes in their behaviours, including increased activity of domestic workers in the production of wax and building wax frames in short time compared to non-treated colonies with magnetized water and these forces have an effect on activating the colonies and on raising brood area.

Perez and Waddington (2000) concluded that feeding colonies with magnetic sugars led to an increase in the workers brood area and continued strength of the colony in the summer, autumn and spring seasons compared to sugary nutrition without magnetization. In a study conducted by Al-Kinani and Qassem (2012) on the effect of feeding water-soluble sucrose in biological performance of honeybee colonies, it was found that the sugar dissolved in magnetized water affected the studied traits and average number of eggs laid by the queen was 789.9 eggs/queen, while the average number of eggs was 551.05 eggs/queen when using sugar dissolved in non-magnetized water, while area of the workers giving an average of 2739.24 cm^2/colony, while the brood area was 1494.36 cm^2/colony when using non-magnetic. Al-Swaty (2017) reached the effect of magnetized food with different magnetic strengths 3000 G, 2000 G and 1000 G and comparative treatment in biological activity of *Apis mellifera* L. honeybee colonies, the open brood area was 3382.67 cm^2/colony, 3024.57 cm^2/colony, 2908.75 cm^2/colony, 2772.81 cm^2/colony respectively and also affected the closed brood area of 3205.91 cm^2/colony, 2834.98 cm^2/colony 2695.63 cm^2/colony and 2547.43 cm^2/colony respectively.

Effect of magnetized food on honey area

Feeding honeybee colonies with magnetized food in the spring season activates bees in collecting nectar from flowers in line with the increase in pollen. It was found that the area of honey in the colonies fed with magnetized food amounted to 20% increase compared to non-fed sects on non-magnetized food, feeding honey bee colonies with diabetic solution and magnetic pollen increased the area of honey by 14.05% when compared to non-nutrient colonies (Alves *et al*., 1997; Moller, 2000). Mattila and Otis (2006) also explained

that feeding honey bee colonies on magnetized food increases honey production.

Hsu *et al*. (2007) pointed to the possibility of employing bio-iron pellets (Bio-mineralization) [(Fe_3O_4), which contain a special magnetite receptor called Megnetoreception within the body of worker honeybees and by exposing them to a magnetic field showing the increase in the size of the body cells, which in turn provoked an increase in calcium ion (Ca^{2+}) in the cells of the nervous system, which was previously associated with Colchicine's and Latrunculin. This condition causes increased bee nervousness and speed of agitation, especially when the process of examination of cells in the sense that exposing the bees to the process of direct magnetization leads to a reduction of agitation and increase its activity in the collection of honey. On the other hand, the researcher proved to increase the quantities of bio-iron granules beneficial to the human body in honey bees after exposure with the magnetization of 1.25 g/cm^3. Mahdi (2009) concluded that the Yemeni honey bee colonies treated with magnetized water in their daily water and food needs gave a clear improvement in their activities in terms of brood rearing, honey storage, nectar collection, pollen and propolis and increased their ability to produce royal food and secretion of wax.

In a study conducted by Al-Kinani and Qassem (2012) on the effect of feeding water-soluble sucrose on the life performance of honeybee colonies, it was revealed that the sugar dissolved in magnetized water affected the studied traits Whereas the rate of honey produced increased to 24,400 kg/hive for colonies treated with sugar dissolved in magnetized water compared to colonies treated with sugar dissolved in non-magnetized water, reaching 14,100 kg/hive.

Tyari *et al*. (2014) pointed to the quality and quantity of honey extracted from the hives based on strong and clean hives, despite the presence of environmental pollutants increase the incidence of diseases, especially bee mite called *Varroa destructor* (Anderson). This injury reduces the quality and quantity of honey. The severity of the infection leads to the killing of beehives, and giving the magnetized water to the bees by placing it directly in the cells or by putting it in the food provided to the bees or through the plants on which the bees feed have led to a significant increase in the number of female workers and collectors of honey. Honey produced by more than 25% also gave strength to the disease. It is also noted that when providing magnetized water with bee food, honey produced was of high quality in terms of changing taste, colour and smell compared to the ordinary honey as well as high therapeutic properties.

Al-Swaty (2017) reached the effect of magnetized food with different magnetic strengths of 3000 G, 2000 G and 1000 G and control on the life activity of *Apis mellifera* L. and found that the effect of magnetized food in the area of sealed honey reached 2024.82 cm^2/colony, 1985.45 cm^2/colony, the pollen area was 1084.17 cm^2/colony, 974.81 cm^2/colony, 921.51 cm^2/colony and 794.10 cm^2/colony respectively, with the highest rate of honey production as 9.80 kg/colony, 8.72 kg/colony, 7.34 kg/colony and 5.92 kg /colony respectively.

Effect of magnetic food on pollen area

The possibility of controlling free flight (flight of surfaces or bees surfaces) and direct it towards food and water sources either by placing magnets (magnetic field) inside the hives or placing the whole hive inside a magnetic field or by controlling the magnetic poles (north and south) and changing the magnetic field intensity then control the direction of flight and increase the activity of bees, which leads to increased activity of the colonies and then increase the number of bees discharged towards food and water sources (Kirschvink *et al*., 1997). Dreller *et al*. (1999) showed that feeding bees with magnetized food encourages the colony to collect pollen and brood rearing continuously. Al-

Hammadi (2001) reported that feeding with pollen supplements encourage honeybee colonies to increase pollen storage when scarce in the field.

In a study conducted by Al-Kinani and Qassem (2012) on the effect of feeding sucrose solution in magnetized water in biological performance of honeybee colonies, the study showed an increase in brood, honey and pollen area and recorded 2739.24 cm^2/colony, 4422 cm^2/colony and 211.17 cm^2/colony respectively in cells treated with sugar dissolved in magnetized water. The weight of wax frames without bees increased in the treatments of sugar dissolved in magnetized water and reached 13786 g/frame, while it reached 8059 g/frame in the treatments of sugar dissolved in non-magnetized water and showed a significant increase in the average of the number of workers discharged to 858.9 worker/ hour versus 423.1 worker/hour in the treatment of sugar dissolved in non-magnetic water, the number of non-occupied tires by 11.24 frames while the average number of tires occupied with 8.24 frames when using dissolved sugar in non-magnetized water. This indicates the effect of magnetized water in increasing food stocked of honey and pollen as well as increasing brood area and the number of bees in the waxy frames, making it more weight.

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