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The feasibility of substituting date syrup for sucrose in honeybee stimulatory feeding in late winter and early spring, in the natural condition of Karbala, Iraq

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Abstract

The date is one of the most nutrient-dense fruit which is low in fat and protein but high in sucrose. Date syrup is rich in macro and micro nutrients. The possibility of replacing the date syrup with sugar in *Apis mellifera* was investigated. For this purpose, the stimulatory feeding effects on the biological and biochemical characteristics were studied, under natural conditions, in Karbala, Iraq. The average of brood rearing area in the sugar syrup (50%) grew over time (during February and March 2019) from 147 to 272.7 inches^2; however, in the other treatments ("date syrup" and "date syrup+ sugar syrup"), there was no increase in brood rearing area. Totally, there was no significant difference in the areas of capped honey storage and pollen storage in honeybee colonies fed various diets. Concerning biochemical features of honey, the highest concentration of diverse chemicals was associated with sugar, while the lowest concentration was associated with date syrup. Furthermore, the honeybees fed with date syrup had an average of 51.64 percent protein, whereas those treated with sucrose syrup had a percentage of 47.5. The highest fat reserve belonged to the honeybees treated with a "sugar syrup + date syrup" with an average of 9.1 %, in comparison with sugar treatment (6 %). The present study revealed that sugar syrup and date syrup treatments resulted in the highest and the lowest average percentage of carbohydrates (43.9% and 37.72%), respectively.

Keywords: Alternative diet, Apis mellifera meda, chemical analysis of honey, kabkab cultivar, biochemical features of worker bees

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Introduction

The honeybee is a member of the order Hymenoptera, superfamily Apoidea, family Apidae, and genus *Apis*. There are nine species of *Apis*, with a total of 24 subspecies (Engel, 1999), four of which are of further importance: *Apis florea* F., *Apis dorsata* F., *Apis cerana* F., and *Apis mellifera* L. (Tahmasbi et al., 2013). Due to its unique lifestyle, prolific honey production, pollination, and ease of reproduction, the European honeybee, *A. mellifera* is the dominant species in most world regions, including Iran, and is frequently utilized by beekeepers. Two species of honeybees are found in Iran, namely *Apis mellifera meda* Skorikov and *Apis florea* F. (Ruttner et al., 1985a, b; Mossadegh, 2014). *Apis mellifera meda* is found through highlands whenever sufficient vegetation is present to support it (Ruttner et al., 1985b). The geographical distribution and eastern border of *A. mellifera* in Iran were first recorded and given by Ruttner et al. (1985b).

The Iranian honeybee, *Apis mellifera meda*, is one of the 24 honeybee races found around the globe, along with northern Iraq, southeastern Turkey, and northern Syria (Parichehreh et al., 2017; Tahmasbi et al., 2018; Qasim Alkinani, 2021). This race appears to be morphologically similar to the Italian race, and in terms of biological qualities, it is a race with high fertility, great collection capacity, excellent overwintering strength, and strong aggressiveness, all of which make it superior to other races. The quantity of food required for overwintering is smaller than in any other races, and spring growth is excellent, reaching its optimum in May or early June. Although the performance of this race is low, the beekeepers usually prefer using this race because of its cost-effectiveness and acceptable overwintering (Tahmasbi et al., 2013).

Similar to other insects, bees have distinct dietary requirements for development, survival, and reproduction, including carbohydrates, proteins, lipids, minerals, vitamins, and water. Bees provide almost all these dietary requirements from honey and flower pollen (Sigel, 2011). The bees also need vitamins that have to be balanced with other nutrients, notably proteins. Pollen grains are rich in water-soluble vitamins. While protein is required for the healthy growth of the workers' hypopharyngeal gland, vitamins are needed to develop brood rearing (Saeedi et al., 2013). Minerals are not collected independently by bees, as they are given by water, nectar, and pollen. Studies indicate that 27 elements are present in pollen grains. Phosphorus and potassium are the two most abundant minerals which are extracted during these decompositions. Calcium, magnesium, sodium, and iron are assumed at the next abundance level (Saeedi et al., 2013).

There are around 2,000 distinct varieties of dates. Date fruits vary in size, shape, and weight according to their growing conditions and kind. The flesh of dates is low in fat and protein but high in sucrose (Al-Farsi & Lee, 2008). Dates contain around 70 percent carbohydrates, the majority of which are sugars. The majority of date sugar is inverted sugar, which is rapidly absorbed by the body. Fructose, glucose, and sucrose are the primary sugars in date in equal proportions. Dates are also an excellent source of fiber and minerals such as iron, potassium, and calcium. Additionally, dates are rich in selenium, copper, potassium, and magnesium. Selenium is a cofactor for the antioxidant enzyme glutathione peroxidase that plays a role in protecting bodily tissues from oxidative stress, particularly the immune system's fight against infections (Baliga et al., 2011).

Date syrup, which is high in natural sugars such as fructose and glucose, is a major byproduct of dates. However, the proportion of sucrose sugars is modest. In addition to being a suitable replacement for unhealthy

sugars or artificial sweeteners, date syrup may also boost the nutritional value of food compositions (Mecklinger & Ruh, 2006).

During late winter and early spring when nectar can be scarce, beekeepers often supplement the natural sources of carbohydrates that honey bees collect, such as nectar, with various forms of carbohydrates such as sucrose and invert sugar. The effect of supplementary feeding with glucose, sucrose, and other carbohydrates on the metabolism of honeybees will be of great interest to the beekeeping industry (Taylor et al., 2019). Hypothetically, the date syrup for the richness of nutrients might be offered to honeybees as a stimulatory feeding in late winter and early spring in natural conditions. It can replace nectar and pollen not only as nutritious food but also for brood rearing. The main objective of this study is to investigate the feasibility of substituting date syrup for sucrose in honeybee stimulatory feeding in late winter and early spring.

Material and Methods

Preparing colonies of honeybees:

The Iranian honeybee *A. mellifera meda* is comprised of nine colonies for three treatments (three repetitions per treatment). These treatments included several methods of feeding the hives, and the concentrations of treatments for the creation of 1000 g of syrup were as follows:

a) First treatment (date syrup): 750 grams of pure date syrup + 250 grams of water

b) Second treatment (date syrup + sugar syrup treatment): 375 grams of pure date syrup + 250 grams of sugar + 375 grams of water.

c) Third treatment (sugar syrup treatment) includes 500 g. of sugar + 500 g. of water.

This study was extended for two months (late winter to early spring), in the natural condition of Karbala, Iraq, during February and March 2019, to assess the impact of varied diets on a variety of parameters. Date syrup was extracted from the kabkab cultivar and was manufactured by providers who extracted date syrup using the cold technique.

Estimation of materials in the alternative diet:

The following methods were used to measure nutrients, including total nitrogen, total sugar, and fat:

1- Measuring the total nitrogen content of nutrients: Micro Dialdehyde technique and treatment conversion (ratio of protein % = percentage of nitrogen × 6.25 protein factor) was estimated.

2- Measuring total sugars: Eynon and Lane make up these sugars. The quantity of sugar in food treatment was determined using the copper reduction technique.

3- Measurement of fatty substances: Fatty substances were extracted using a Soxhlet apparatus and a solvent containing petrochemical component (40-60), and their quantity was determined using the following equation:

$$\text{Formula} = [\text{fat mass (g)} / \text{sample mass (g)}] \times 100$$

Nutrition period

Nutrition in late winter and early spring was tested to assess the effect of feeding of date syrup vs. sugar on the hive activity, i.e. the area of brood rearing, the area of stored pollen, and also the area and weight of stored honey. The hive activity rises at the beginning of the season (spring). Also, the effect of providing diets on the biochemical compositions of bees and the quality of honey produced was investigated.

Brood, honey, and pollen area in honeybee colonies

For this purpose, a frame divided by wire into equal sized subdivisions (one square inch) was used. Before the experiment, this special frame was put on individual frames in all hives, and photos were taken of both sides

of each frame. Whole adult honeybees were removed from each frame before photographing. This method was repeated every two weeks until the end of the experiment. The areas were estimated from the frame photographs using ImageJ version 1.47 image analysis software (W. Rasband, National Institutes of Health, USA).

Determining the quantity of honey produced

For this purpose, at the end of the experiment, honey-containing frames were gathered, and the honey's weight was determined after extraction. Determining the area of honey at the beginning of the experiment showed that the initial amount of honey between the treatments was not significantly different ($F = 2.369$; $df = 2, 6$; $P = 0.174$).

Chemical analysis of honey:

A chemical analysis of honey generated by bees treated with different diets was conducted (Bogdanov et al., 1999) to determine the changes in minerals and honey's potency, as follows:

a- Determining the concentration and moisture content: It will be conducted utilizing a Leica Refractometer (Automatic Refractometer with LCD digital display and simple 3 step measurement)

b- Determining pH: It will be conducted using a pH meter (Sigma-Aldrich, Model ST300-G)

c- Determining the sugars: The Fehling technique will be utilized to determine both reducing sugars and sucrose (Scales, 1915).

d- Using an electric furnace, the quantity of ash was measured (Shimaz Co., 1500 degrees Celsius).

Notably, this experiment aims to establish the quality of honey for bee nutrition, not to determine its nutritional value for humans.

Effect of alternative diets on biochemical compositions of bees

This experiment was performed during two months, from late winter 2019 to early spring) to determine the impact of date syrup on the aforementioned worker bee parameters.

The moisture of bees

Newly-emerging workers (0 to 24 hours) were sampled. For each treatment, 1 g of bees was chosen randomly, dried at 100 °C for 90 minutes, and then the moisture content was determined using the following formula:

Body moisture percentage = (fresh weight minus dry weight / fresh weight) × 100

Total protein content

Sampling was performed on newly-emerging workers with a lifetime of 0 to 24 hours. Also, 0.2 g of each protein was picked and calculated using the Bradford technique in each treatment (Kruger, 1994).

Fat content

A sampling of newly-emerging workers with a life expectancy of 0-24 hours was conducted. Five grams were chosen for each treatment, and the amount of fat was computed using the Soxhlet solution of petroleum products (40-60) (Ayodele et al., 2022).

Total carbohydrate

Total carbohydrate content was determined using the following equation:

Total carbohydrate content = 100 minus (protein ratio + fat ratio + pollen ratio)

Ratio of ash (metals)

Sampling freshly emerging worker bees with a lifetime of 0 to 24 hours; 2 g of each sample was dried at 60 degrees Celsius for 30 minutes and then burnt at 550 degrees Celsius for 10 hours.

Ash ratio = [total weight of ash/weight of the sample (g)] × 100

Statistical research

The Kolmogorov-Smirnov test was run to determine the normality of the data before analysis. The findings were produced in the form of a complete randomized design (CRD) of several treatments using one-way analysis of variance (One-Way ANOVA) and, where there were two variables, two-way analysis of variance (Two-Way). The

SPSS statistical program examined ANOVA results. If the difference in means was significant, a comparison was conducted using Tukey's test to separate means.

Results and Discussion

Effects of alternate meals on biological aspects of honeybees

Brood rearing area

According to the findings of a two-way analysis of variance, the area covered by brood cells was unaffected by the main effect of various diets, the main effect of different sampling dates, and the interactions between these two factors (Table 1).

During the four sample dates, the diets did not influence the number of cells sealed (Table 2). The findings revealed that the average level of brood reared in the sugar treatment increased over time (from 147 to 272.7 inches^2); however, in the other treatments, there was no rise in the brood rearing area (Table 2). The highest average was for sugar syrup with 272.7 inches (21 March), whereas the lowest average was for date syrup with 150 inches (20 February).

In a study performed in Baghdad (Iraq) during summer, autumn, and spring, on the effects of several diets, such as sucrose solution (60 percent), date syrup (ascetic type), date tree pollen, bean flour, and chickpeas, alone and together, the greatest number of males was observed when the honeybees were fed with a combination of sugar syrup, bean seed flour, and date pollen (Al-Zubaidi, 1998).

Capped honey stored area

According to the two-way ANOVA, the main effects of diets and sampling dates on the area of stored honey were significant, but their interaction effect was not significant (Table 3).

Table 1- Two-way ANOVA of the effects of diets (Date syrup/ Date syrup+ sugar/ sugar syrup) on brood rearing area (No. of cells sealed) in the sampling dates at the natural condition of Karbala, Iraq, during February and March 2019.

	Areas of brood cells		
	Two treatments		
Source of variation	d.f.	*F*	*P*
Different diets	2	0.319	0.73
Sampling dates	3	2.22	0.112
Interaction between factors	6	0.508	0.796
Residual d.f.	35		

Table 2- Mean (± SE) of brood area (No. of cells sealed) (Inch^2) in hives fed with dietary treatments (date syrup/ date syrup + sugar syrup /sugar syrup) in the sampling dates at the natural condition of Karbala, Iraq, during February and March 2019.

	Treatments (syrup)			*F*	*P*
Sampling date	Date	Date + Sugar	Sugar		
6 Feb. 2019	151.3 ± 4.1 Aa	152.7 ± 3.8 Aa	147 ± 1.15 Abc	0.801	0.492
20 Feb. 2019	150 ± 21.3 Aa	162.3 ± 59.2 Aa	123.7 ± 7.9 Ac	0.291	0.757
2 Mar. 2019	151.3 ± 56.9 Aa	153 ± 68.3 Aa	174.7 ± 8.6 Abc	0.064	0.939
21 Mar. 2019	174.7 ± 57.5 Aa	213.3 ± 64.2 Aa	272.7 ± 10.3 Aa	0.97	0.432
	F= 0.08; *P*= 0.969	*F*= 0.27; *P*= 0.843	*F*= 70.08; *P*<0.001		

Means in each row bear the same upper case letter, and means in each column bear the same lower case letter were not significantly different (Tukey; $P > 0.05$).

The finding on February 20, 2019, revealed a significant difference between the honey storage area of the hives treated with "sugar syrup" and those treated with "date syrup," although, on other dates, sampling did not reveal any difference (Table 4).

The capped honey stored area in beehives treated with sugar syrup was 73.83 inches^2, while it was 50.17 and 39.08 inches^2 in bee hives treated with "date syrup + sugar", and date syrup, respectively.

Consistent with Hussein (1983) research, the current study found that feeding colonies with sugar syrup increased honey stored area. Other research has shown that sugar syrup has a significant encouraging effect on worker bees to gather and store honey, because workers prefer to consume sugars that are substitutes for honey. As an explanation, bees are much simpler to feed sugar than honey because they need to drink more water to dilute and consume the honey (Simpson, 1964).

Our research indicated that the honey stored area was reduced over time across all treatments. This may be explained by the death of a large number of elderly workers, which decreased the amount of honey produced in the hives. Moreover, the low temperature increased the level of honey consumption inside the hives.

Pollen stored area

According to the findings of a two-way analysis of variance, the main effects of diets and sampling dates were significant on the stored pollen area, but their interaction effect was not significant (Table 5).

There was no significant difference in the areas of pollen storage in bees fed various diets; nevertheless, the sugar syrup treatment resulted in the largest average area of pollen storage (141 inches^2) (Table 6). According to the findings of this research, the pollen stored areas in the hives increased by 32% when treated with sugar syrup as opposed to date syrup (Table 6).

In another study conducted in the natural settings of Baghdad (Iraq) on the influence of various nutrients, the highest level of pollen was gathered in summer and fall when workers were fed with a combination of date syrup, bean seed flour, and pollen from date trees (Al-Zubaidi, 1998).

Table 3- Two-way ANOVA of the effects of diets (Date syrup/ Date syrup+ sugar/ sugar syrup) on the area of honey cells in the sampling dates, at the natural condition of Karbala, Iraq during February and March 2019.

	Areas of brood cells		
	Two treatments		
Source of variation	d.f.	*F*	*P*
Different diets	2	102.8	<0.001
Sampling dates	2	8.136	0.003
Interaction between factors	4	1.379	0.281
Residual d.f.	26		

Table 4- Capped honey cells (Mean ± SE/ inch^2) in hives fed with feeding treatments (Date syrup/ Date syrup+ sugar/ sugar syrup) in the sampling dates at the natural condition of Karbala, Iraq, during February and March 2019.

	Treatments (syrup)			*F*	*P*
Date	Date	Date + Sugar	Sugar		
6 Feb. 2019	105.3 ± 16.5 Aa	112 ± 8.5 Aa	141 ± 10.5 Aa	2.369	0.174
20 Feb. 2019	43.7 ± 14.5 Bb	67.7 ± 12.1 ABb	96.7 ± 6.8 Ab	5.2	0.049
2 Mar. 2019	0.0 ± 0.0 Ac	1.3 ± 1.3 Ac	8 ± 5.7 Ac	1.616	0.275
	F= 17.4; *P*=0.003	*F*= 41.94; *P*<0.001	*F*= 72.37; *P*<0.001		

Means in each row bear the same upper case letter, and means in each column bear the same lower case letter were not significantly different (Tukey; $P > 0.05$).

Table 5- Two-way ANOVA of the effects of diets (Date syrup/ Date syrup+ sugar/ sugar syrup) on the stored pollen area in the sampling dates, at the natural condition of Karbala, Iraq, during February and March 2019.

	Areas of brood cells		
	Two treatments		
Source of variation	d.f.	*F*	*P*
Different diets	2	5.51	0.011
Sampling dates	3	79.26	<0.001
Interaction between factors	6	0.895	0.514
Residual d.f.	35		

Table 6- Capped pollen cells (Mean ± SE/ inch^2) for hives fed with the feeding treatments (Date syrup/ Date syrup+ sugar/ sugar syrup) in the sampling dates, at the natural condition of Karbala, Iraq, during February and March 2019.

	Treatments (syrup)			*F*	*P*
Date	Date	Date + Sugar	Sugar		
6 Feb. 2019	107.3 ± 17.2 Aa	113.3 ± 7.8 Aa	141 ± 10.5 Aa	2.062	0.208
20 Feb. 2019	9.3 ± 4.8 Ab	10.3 ± 6.4 Ab	27 ± 11.2 Ab	1.564	0.284
2 Mar. 2019	24 ± 1 Ab	19 ± 1.5 Ab	20.3 ± 6.2 Ab	0.478	0.642
21 Mar. 2019	23 ± 1 Ab	24.3 ± 5.2 Ab	54.7 ± 19.2 Ab	2.44	0.168
	F= 24.97; *P*<0.001	*F*= 70.02; *P*<0.001	*F*= 19.2; *P*=0.001		

Means in each row bear the same upper case letter, and means in each column bear the same lower case letter were not significantly different (Tukey; $P > 0.05$).

Shawer (1987) demonstrated that the climatic conditions of each region, particularly temperature, are one of the most significant factors influencing the activity of bees in terms of food consumption and reproduction and that pollen harvest is directly proportional to access pollen-rich plants, the number of sealed brood cells, and climate suitability (Al-Sayeq & Mustafa, 2003; Elsaiegh & Mustefa, 2003).

Food availability has a remarkable influence on colony growth and development (Khoury et al., 2013). Helmich and Rothenbuhler, (1985) revealed that there is a clear correlation between the larger number of brood cells and the stored pollen area, which both directly depend on the hive population.

The current investigation revealed that the stored pollen area in all treatments shrank with time, indicating pollen consumption and a shortage of pollen supply from natural resources at the sample date (Table 6). These results are consistent with studies of Al-Jubouri and Muhammad Amin (2005) which reported that pollen levels are reduced in winter months.

Total weight of the stored honey

According to the data, the type of nutritional treatment had a significant influence on the quantity of honey stored by the end of the experiment ($F = 80.07$; df = 2, 6; $P < 0.001$), so that more honey was produced and stored in beehives fed with sugar syrup (10.5 ± 0.27 Kg.) than colonies fed with a combination of date and sugar syrup (7.18 ± 0.35 Kg.). The date syrup treatment produced the lowest weight of honey (5.12 ± 0.19 Kg.).

In a study conducted in the natural conditions of Baghdad (Iraq), it was found that the beehives treated to sugar syrup produced the highest amount of honey during summer and autumn, but the amount of honey in spring

when bees were fed "date syrup + bean seed powder + date pollen" was higher than sugar syrup treatment (Al-Zubaidi, 1998). Al-Zubaidi (1998) also used date syrup treatment, and contrary to our results, the production of bee hives in this treatment was higher than in the sugar treatment. From the comparison of the results obtained and this study, it can be concluded that bean seed powder and date pollen can be the main factor in increasing honey production, and probably the combination of "date syrup + bean seed powder + date pollen" can bring the best results. Considering that the increase in honey production is the result of a larger hive population (Harbo, 1986), and the use of pollen in supplementary food plays an important role in raising broods (Ulla et al., 2021), it seems logical to produce more honey in hives treated with such a combination.

Chemical characteristics of dietary sources

Chemical component content (mean ± SE) of date syrup which was extracted from the kabkab cultivar were for Brix (78.5 ± 0.01 %), pH (5.3 ± 0.01), reductive sugars before invert (73.77 ± 0.30), reductive sugars after invert (77.44 ± 1.01), sucrose (3.49 ± 0.86 %), glucose (32.74 ± 1.5 %), fructose (41.04 ± 1.67 %), fructose/glucose ratio (1.26 ± 0.12), and ash (2.17 ± 0.02 %).

This research was performed to determine the biochemical features of honey obtained from various treatments (Table 7). The difference in the quality of honey produced due to feeding the supplemented diets can affect the biological characteristics of worker bees.

Among the several treatments used to feed the beehive, the greatest Brix (the measurement in percentage by weight of sucrose in pure water solution) was associated with sugar syrup, while the lowest Brix was associated with date syrup ($F = 12.88$; $df = 2, 6$; $P = 0.007$). The greatest pH value was associated with date syrup, whereas a combination of date syrup and sucrose and sucrose syrup had the lower pH value, respectively ($F = 66.93$; $df = 2, 6$; $P < 0.0001$). In terms of reductive sugars before inversion ($F = 1.77$; $df = 2, 6$; $P = 0.249$), reductive sugars after inversion ($F = 1.22$; $df = 2, 6$; $P = 0.36$), percentage of sucrose ($F = 0.05$; $df = 2, 6$; $P = 0.951$), percentage of glucose ($F = 0.87$; $df = 2, 6$; $P = 0.467$), percentage of fructose ($F = 2.26$; $df = 2, 6$; $P = 0.186$), and fructose/glucose ratio ($F = 2.19$; $df = 2, 6$; $P = 0.194$) were not significantly different in any of the studied treatments. The highest ash percentage was associated with date syrup, whereas a combination of date syrup and sucrose, and sucrose syrup had the lower ash, respectively ($F = 171.57$; $df = 2, 6$; $P < 0.001$) (Table 7).

Table 7- Chemical component content (mean ± SE) of honey produced by honeybees from different treatments.

	Treatments		
Parameters	Date syrup	Date syrup+sugar	Sugar
Brix (%)	79.33 ± 0.33 b	81.00 ± 0.58 a	82.17 ± 0.17 a
pH	4.49 ± 0.052 a	4.37 ± 0.012 b	4.01 ± 0.002 c
Reductive sugars before invert	61.42 ± 3.45 a	68.60 ± 3.80 a	70.06 ± 3.16 a
Reductive sugars after invert	78.97 ± 2.11 a	84.02 ± 5.13 a	88.18 ± 4.66 a
Sucrose (%)	16.67 ± 3.62 a	14.64 ± 8.39 a	17.19 ± 4.83 a
Glucose (%)	36.34 ± 0.60 a	33.94 ± 2.10 a	34.53 ± 0.80 a
Fructose (%)	25.08 ± 3.81 a	34.67 ± 4.43 a	35.52 ± 3.24 a
Fructose/Glucose ratio	0.69 ± 0.11 a	1.03 ± 0.17 a	1.03 ± 0.10 a
Ash (%)	0.97 ± 0.04 a	0.65 ± 0.01 b	0.3 ± 0.001 c

Means in each row bear the same lower case letter were not significantly different (Tukey; $P > 0.05$).

Effects of diets on biochemical compositions of the body of worker bees

Protein content

The statistical analysis revealed a significant difference in the percentage of body protein in the examined bees (Table 8). The honeybees fed with date syrup had an average protein ratio of 51.64 percent, whereas those treated with sugar syrup had an average protein ratio of 47.5 percent. This research revealed that a large proportion of the protein in date syrup could be absorbed and retained in the bodies of worker bees, but sugar syrup had no protein value.

There was a significant difference in the mean protein ratio between date syrup and sugar syrup and between date syrup and "date syrup + sugar syrup", but there was no significant difference between sugar syrup and the "date syrup + sugar syrup" (Table 8).

In a research conducted in the natural environment of Baghdad (Iraq) on the effects of various diets, the body protein percentage of worker bees was affected by the type of diet. The worker bees fed sucrose syrup, and date pollen had higher protein (57.17 percent) than those fed naturally (46.58 percent) (Al-Zubaidi, 1998). Considering that date pollen is a rich source of protein (Ulla et al., 2021), similar to the results of the present study, the use of this supplement led to a higher percentage of protein in the body of workers.

Many researchers have concentrated on producing an ideal supplemental protein diet for bees that is rich in the required nutrients, (Doull, 1980; Herbert, 1992; Cremonez et al., 1998, Dastouri & Maheri-Sis, 2007), while it is healthy and readily absorbed, because more dietary protein levels than needed resulted in lower survival and reduced population growth (Zheng et al., 2014).

Fat content

Insects mostly store energy as triglycerides, which results in the binding of amino acids to cholesterol. Fats are superior to carbs for energy storage, and when fat-containing supplements are consumed, some sugars (glucose) may be converted to fatty acids.

The statistical analysis shown in Table 8 revealed a significant difference in the percentage of body fat between the treatments. The highest fat reserve belonged to bees treated with a "sugar syrup + date syrup" with an average of 9.1 %, whereas the lowest fat belonged to bees treated with sugar syrup with an average of 6 %.

Abdullah (1998) reported that when honeybees were fed a sugar solution, the fat content of their bodies increased to 6.7% (Abdullah, 1988). Al-Jubouri & Muhammad Amin (2005) also reported that the amount of fat in worker bees' bodies has grown from 7.4% to 8.7%, when fed with a sugar solution.

Table 8- The influence of the feeding regimens (date syrup/ date syrup + sugar surup/ sugar syrup) on the biochemical features of adult worker bees.

Characters	Treatments (syrup)			*F*	*P*
	Date	Date + Sugar	Sugar		
Protein (%)	51.6 ± 0.35 a	48.6 ± 1.05 ab	47.5 ± 0.32 b	10.378	0.011
Fat (%)	7.6 ± 0.26 b	9.1 ± 0.62 a	6 ± 0.12 c	34.142	0.001
Carbohydrate (%)	37.72 ± .16 b	39.4 ± 1.57 b	43.9 ± 0.42 a	11.443	0.009
Ash (%)	3.07 ± 0.09 a	2.8 ± 0.19 a	2.6 ± 0.12 a	2.49	0.163
Humidity (%)	74.97 ± 0.3 a	73.7 ± 0.61 ab	72.5 ± 0.12 b	9.397	0.014

Means in each row bear the same lower case letter were not significantly different (Tukey; $P > 0.05$).

In a study conducted in the natural conditions of Baghdad (Iraq) on the effect of various supplements on fitness gained by honeybees, the highest amount of fat (8.48 %) was found in the bodies of workers fed with date syrup + date pollen (Al-Zubaidi, 1998).

Carbohydrate content

In all treatments, statistical analysis revealed a substantial variation in the proportion of total carbohydrates in the worker bee's body, when treated to the mentioned diets, such as sugar syrup and date syrup treatments, which resulted in the highest (43.9%) and lowest (37.72%) average percentage of carbohydrates, respectively. There was no significant difference between the percentages of carbohydrates of bees fed with date syrup and "date syrup + sugar syrup" (Table 8).

Quantity of body ash

The non-organic residues remaining in the bodies of bees after combustion may indicate the benefit that bees gain from the alternatives, supplements, and minerals present in these substances.

The statistical analysis revealed no significant differences in the ash proportion of worker bees' bodies across treatments (Table 8). The average percentage of ash associated with date syrup treatment was 3.07 percent, whereas the average percentage of ash associated with sugar syrup treatment was 2.6 percent.

In a study conducted in the natural environment of Baghdad (Iraq), giving honey and pollen replacements and supplements to worker bees enriched their mineral content. When worker bees were given a mixture of date syrup and date pollen, the greatest minerals (6.51 percent) were detected in their bodies (Al-Zubaidi, 1998). In the present study, more minerals were found in worker bee bodies fed with date syrup than those fed with sugar syrup, although this difference was not significant.

Body moisture

According to Table 8, a statistically significant difference was observed between bees fed with date syrup (74.97 %) and sugar syrup (72.5) in the amount of body moisture. The proportion of moisture in the body of bees is referred to as Sap Coefficient, and it has been demonstrated that bees with a lower proportion of body moisture can tolerated better the environment with lower temperatures in winter (Al-Ali & Al-Baqi, 1987).

Some researchers have reported that the body moisture of honeybees after regular feeding with sugar syrup ranges from 72.0 to 77.3%. (Haydak, 1936; Abdullah, 1988).

Conclusion

In conclusion, despite the benefits of using date syrup in some biological and biochemical characteristics, the application of date syrup in this setup is not recommended, suggesting additional research to find a better concentration of date syrup in combination with sugar.

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امکان سنجی جایگزینی شربت خرما به جای ساکارز در تغذیه تحریکی زنبور عسل در اواخر زمستان و اوایل بهار در شرایط طبیعی کربلا، عراق

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چکیده

خرما یکی از مفیدترین و مغذی‌ترین مواد غذایی می‌باشد و دارای چربی و پروتئین پائین، اما غنی از ساکارز است. شیره‌ی خرما بدلیل دارا بودن انواع مواد ریز و درشت مغذی می‌تواند انواع مواد غذایی مورد نیاز زنبور را تأمین کند. در این مطالعه، امکان جایگزینی شیره خرما بجای شکر، در تغذیه‌ی تحریکی زنبورعسل *Apis mellifera* L. بررسی شد. به این منظور، اثر تغذیه‌ی تحریکی با شیره خرما در مقایسه با شکر، روی خصوصیات زیستی و بیوشیمیایی زنبورعسل در شرایط طبیعی کربلا بررسی شد. بر اساس نتایج به‌دست آمده، در تیمار تغذیه با شربت شکر (۵۰٪)، با گذشت زمان (بین ماه‌های بهمن و اسفند) میانگین سطح نوزادان پرورش یافته افزایش یافت (از ۱۴۷ به ۲۷۲/۷ اینچ[۲])، اما در سایر تیمارها ("شیره خرما" و "شیره خرما+شربت شکر") افزایش سطح پرورش نوزادان دیده نشد. در مجموع تفاوت معنی‌داری در سطح عسل ذخیره شده و همچنین گرده ذخیره شده در کندوهای تغذیه شده با رژیم‌های مختلف غذایی دیده نشد. در ارتباط با ویژگی‌های بیوشیمیایی عسل، بیشترین درصد غلظت ترکیبات مختلف مربوط به شکر و کمترین مقدار آن مربوط به شیره خرما بود. در ارتباط با اثرات مواد غذایی جایگزین روی ویژگی‌های بیوشیمیایی بدن زنبورهای کارگر، بالاترین نسبت پروتئین مربوط به زنبورهای تیمار شده با شیره خرما با میانگین ۵۱/٦٤ درصد و کمترین نسبت پروتئین مربوط به زنبورهای تیمار شده با شربت شکر با میانگین ٤٧/٥ بود. همچنین زنبورهای تیمار شده با شیره خرما دارای بیشترین میزان درصد رطوبت با میانگین ۷٤/۹۷ درصد و زنبورهای تیمار شده با شربت شکر دارای کمترین میزان درصد رطوبت با میانگین ۷۲/۵ درصد بودند. بیشترین ذخیره چربی بدن، در زنبورهای تیمار شده با مخلوط "شربت شکر و شیره خرما" با میانگین ۹/۱ درصد و کمترین ذخیره چربی مربوط به زنبورهای تیمار شده با شربت شکر با میانگین ٦ درصد بود. پژوهش حاضر همچنین نشان داد که بیشترین درصد کربوهیدرات مربوط به تیمار شربت شکر با میانگین ٤۳/۹ درصد و کمترین درصد کربوهیدرات مربوط به تیمار شیره خرما با میانگین ۳۷/۷۲ درصد بود.

کلیدواژه‌ها: رژیم غذایی جایگزین، *Apis mellifera meda*، تجزیه شیمیایی عسل، رقم کبکاب، ویژگی‌های بیوشیمیایی زنبورهای کارگر

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