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Physiological Characteristics of Honeybee (*Apis mellifera* L.) Colonies Fed with Commercial Glucose

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Abstract: The present study was conducted in order to investigate the effect of feeding commercial glucose on honeybees. Some physiological characteristics of colonies such as colony population, brood area, weight gain in nectar flow and honey production were examined in May to August, 2009. Two different compositions were prepared using commercial glucose (group 1) and sucrose (group 2). Control group was not given any feeding. Prepared syrups were given to colonies according to Spring and Autumn feeding principles. There was a significant difference between groups with regard to the amount of consumed food and weight gain. Colonies in group 2 had the highest honey yield (35.20±1.50 kg/colony) and consumed more food (12.59±0.50 kg/colony) than group 1 and control. Colonies fed with commercial glucose had the smallest bee population and brood production compared to group 1 and control. A significant positive correlation ($r = 0.76$, $p<0.05$) was found between bee population in Spring and honey production. There was a significant relationship ($p<0.05$) between brood production and colony population ($r = 0.44$). These results suggest that feeding commercial glucose is not recommended as supplementary feed for beekeeping.

Key words: Honeybee (*Apis mellifera*), commercial glucose, supplementary feeding, colony performance, production

INTRODUCTION

Honeybee nutrition is very important as well as other livestock. In order to reach the desired level of colony strength required nutrition by honeybees should be provided from outside. Reducing Wintering losses with young generations before Wintering providing strong honey bee population in Spring and high production performance depends on fall maintenance and feeding. The 2:1 ratio (2 part sugar + 1 part water) sugar syrup should be used for fall feeding (Genc and Aksoy, 1993).

Colonies should be fed in early Spring with vitamin and pollen cake till matured to the climate and pasture conditions in order to ensure their rapid growth (Zmarkcki and Marcinovski, 1979). They also should be fed in late Spring with 1:1 concentration of sugar and water by volume (Dodologlu *et al*., 2004).

Recently, beekeepers started to use commercial glucose consumed greedily by bees. Glucose is produced commercially via the enzymatic hydrolysis of corn starch. However, the use of commercial glucose affects bees digestive system and leads to shortness of lifespan in all living organisms.

Starch is main source of glucose in commercial production. Producers convert starch into glucose using enzymatic hydrolysis process. This enzymatic process has two stages. These enzymes hydrolyze starch into smaller carbohydrates (average 5-10 glucose units each) at 100°C for 1-2 h. Saccharification is the second step in the process. The glucoamylase enzyme from the fungus *Aspergillus niger* is used to hydrolyzed starch completely glucose along with a little maltose and isomaltose. The reaction conditions are pH 4.0-4.5, 60°C and a carbohydrate concentration of 30-35% by weight so that starch can be converted to glucose at 96% yield within 1-4 days. It is possible to obtain higher yield using more dilute solutions but this approach requires larger reactors and processing a greater volume of water and is not generally economical. The resulting glucose solution is then purified by filtration and concentrated in a multiple-effect evaporator. Solid D-glucose is then produced by repeated crystallizations (Anonymous, 2011).

In this study, researchers investigated some physiological characteristics of honeybee colonies fed with commercial glucose and sucrose.

MATERIALS AND METHODS

Establishment of the experimental colonies and feeding compositions: A total of 45 colonies were divided into 3 groups with 15 colonies into each group. Colonies were

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kept in Langstroth hives in standard size manufactured by Development Foundation of Turkey (TKV). Colonies were headed by Caucasian queens raised in Erzurum. Experimental colonies were equalized to contain a food stores (three-four combs containing honey and pollen) and adult bee population (ca. ten frames covered with bees).

Syrups prepared in two different compositions (group 1: commercial glucose and group 2: sucrose) were given to feeding colony groups according to feeding principles for Spring and Autumn. Control group (group 3) did not receive any feeding. Sucrose syrup was prepared at ratio of 1:1 (1 unit sugar + 1 unit water) for Spring and a ratio of 2:1 for Autumn feeding. Each colony was given 0.5 L syrup daily for the experimental period. Colonies in feeding groups were fed in fall when weather conditions did not allow the bee flight when honeybees broke out Winter cluster to fly and in early Spring before nectar flow whenever required.

Determination of physiological characteristics of colonies: Evaluation of physiological characteristics of colonies were determined as survival rate, Wintering ability, food consumption, adult bee population, amount of brood area and weight gain and honey yield. The number of colonies dying or losing their queens at various times during Winter or production periods was recorded as survival rate. The Wintering abilities in the experimental colonies were determined taking into consideration the population loss in colonies surviving until Spring and food consumption in these colonies at the time of Wintering. The amount of food consumption was weighed in feeding groups received different content of food.

Adult bee population was estimated at 30 days intervals during 4 months period. Measurements of worker brood area were determined by measuring capped brood using standard frame divided into square inches from May to July (Fresnaye and Lensky, 1961). In order to determine the beginning and ending dates of nectar flow period, the strongest colony was weighed on a hive scale in June. All experimental colonies were weighed at the beginning and end of nectar flow period in order to determine nectar gain weight during nectar flow. The weight differences before and after honey harvest was evaluated as the colony's honey yield.

Statistical analysis: Data on Wintering ability, food consumption, honey yield and weight gain during nectar flow were arc-sine transformed and subjected to analyses of variance and protected LSD tests to separate statistical differences between groups. Data on amount of brood area was log (10) transformed to reduce the heterogeneity of variance and correlated with bee population and honey yield using Pearson correlation analyses (Sokal and Rohlf, 1981).

RESULTS

Survival: In experimental colonies, 66.66% of colonies in group 1, 93.33% of colonies in group 2 and 80.00% of colonies in group 3 were able to survive over Winter. The difference between groups in terms of survival rate during Winter or production period was not found to be statistically significant (Table 1).

Wintering ability: Wintering ability of colonies was found significant between groups and the percentage Wintering of group 1, 2 and control were recorded to be 44.40, 36.62 and 26.57%, respectively (Table 2). The difference between groups was found significant.

The amount of consumed food in colonies in over Winter was significantly different among groups. The highest (12.59±0.50 kg/colony) food consumption amount was obtained in group 2.

Colony weight gain and honey production: Colonies fed with sucrose (group 2) gained more weight (65.85±2.69 kg/colony) than that of group 1 (20.74±1.50 kg/colony) and group 3 (35.45±2.06 kg/colony) and the differences between groups were found significant. The highest honey yield (35.20±1.50 kg/colony) was obtained in group 2. The differences between the groups were significant in respect to honey yield (Table 2).

These results clearly indicate that honeybees respond more to sucrose than that of commercial glucose. Colonies fed with commercial glucose had less weight gain during nectar flow period.

Number of frames and brood area: Table 3 shows that statistically significant differences were found between the experimental groups and control groups regarding the size of sealed brood area and bee population. Colonies fed with sucrose showed highest brood area (33096.6±28468.0) in July and the number of frame covered with bees (28.6±0.9) in August. The sucrose-fed colonies had more bee population and brood activity in all months.

Table 1: Number of colonies and percentage survival of the groups

Period (over Wintering or production)	Group 1	Group 2	Control
Over wintering			
Experimental colonies (n)	15.00	15.00	15
Dead colonies (n)	5.00	1.00	3
Survival rate (%)	66.66	93.33	80
Production			
Experimental colonies (n)	10.00	14.00	12
Dead colonies (n)	0.00	0.00	0
Survival rate (%)	100.00	100.00	100

Table 2: The effect of feeding compositions on Wintering ability, food consumption, weight gain and honey yield

Groups	Wintering ability (%)	Food consumption (kg/colony)	Weight gain during nectar flow period (kg/colony)	Honey yield (kg/colony)
1	44.401.83[a]	8.410.33[a]	20.741.50[a]	11.310.85[a]
2	26.571.74[b]	12.590.50[b]	65.852.69[b]	35.201.50[b]
Control	36.621.57[c]	3.500.00[c]	35.452.06[c]	19.291.15[c]

Means in each column followed by different letters are significantly different at the $\alpha = 0.01$ level

Table 3: Sealed brood area and bee population in the experimental colonies fed with commercial glucose and sucrose

	Sealed brood area (cm^2)			Number of bee population			
Groups	May	June	July	May	June	July	August
1	562.4±27.0[b]	1850.4±41.4[a]	1464.3±47.7[a]	5.0±0.2[a]	6.6±0.3[a]	10.1±0.9[a]	14.6±0.40[a]
2	1609.2±619.0[a]	10715.8±4591.6[b]	33096.6±28468.0[b]	7.8±0.2[b]	12.4±0.4[b]	19.1±0.5[b]	28.6±0.90[b]
Control	621.8±19.4[b]	3966.1±766.9[c]	3113.4±155.5[c]	6.8±1.0[c]	8.9±0.3[c]	12.4±0.4[c]	21.25±1.1[c]

[a-c]Means with no common superscript in a column within a parameter differ ($p<0.05$)

DISCUSSION

Survival: Survival values for Wintering and production periods in sucrose groups were given in an early study as 83 and 100%, respectively (Dodologlu *et al*., 2004) in another study, survival values for Wintering for colonies fed with sucrose was 73.33% (Dodologlu and Genc, 2002).

In other study, High Fructose Corn Syrup (HFCS) which is produced corn star using enzyme technology was used to feed honeybees as a nectar substitute. The researchers found HFCS can have negative effects on colony health and survival (Degrandi-Hoffman *et al*., 2012).

Wintering ability: The smallest bee population during the Wintering period was observed in the commercial glucose group. Food consumption values in Winter period in this study were lower than the finding (8.60±0.52 kg/colony) reported from another research for colonies fed with sucrose (Dodologlu *et al*., 2004). In another study, food consumption value for sucrose-fed colonies was reported 1.90 kg/colony (Dodologlu and Emsen, 2007).

Colony weight gain and honey production: Weight gain values during nectar flow period obtained in this study were found low in colonies received commercial glucose. Average weight gain during nectar flow period for different feeding sucrose supplements was found to be 29.20±2.93, 27.00±1.61, 19.80±1.71 and 27.20±2.23 kg/colony (Dodologlu and Emsen, 2007). In another study, average weight gain during nectar flow period for colonies fed with sucrose was 15.80±0.87 and 14.86±0.79 kg/colony (Dodologlu *et al*., 2004).

The highest honey production was in group 2 and control whereas colonies received commercial glucose did not have high honey yield especially compared to control. In a study, the average honey yield on colonies fed with sucrose was 31.0 kg/colony (Sahinler *et al*., 2005).

Number of frames and brood area: Group 2 formed larger brood area and adult bees than did group 1 and control. The data obtained in the current study for the highest number of frames of bees in the month of August was higher than the findings 11.48±0.20 reported for colonies fed with sucrose (Dodologlu *et al*., 2004). The highest brood production value for group 2 obtained in this study was higher than the values (2177.84±81.09 and 1976.61±38.36) recorded, respectively (Dodologlu *et al*., 2004; Dodologlu and Emsen, 2007). In another study, researchers used different sugar supplement feedings such as sugar syrup, rice bran syrup, maize syrup, banana syrup and pumpkin syrup per day at an interval of 3 days. It was found that feeding honeybees sugar syrup increased of brood cells by 53.5%, brood frames by 37.1% and frames covered by bees 32.0% (Neupane and Thapa, 2005).

It is seen that there is a direct relation between brood production and the number of frames of bees. An increase in brood activity causes an increase in the number of frames covered with bees. In the current study it was found that there was a significant relationship ($p<0.05$) between brood production and colony population ($r = 0.44$) which has been reported by many others (Dodologlu *et al*., 2004; Dodologlu and Genc, 2002; Szabo, 1980).

Supplementary feeding is necessary so as to prevent starvation in colonies, overcome pesticides damages, treat colonies by adding some medicines to feed, produce queen bee, packages bee and cluster and above all accelerate brood activity of colonies. However, appropriate feeding schedule, preparing appropriate feed composition and feeder types must be selected correctly to provide the expected benefits from foods.

CONCLUSION

It is concluded that feeding commercial glucose was less profitable than feeding sucrose supplement. Colonies

fed with commercial glucose had lower survival rate and less honey yield, adult bee population, brood activity and weight gain than even control.

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