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Glycemic index values of monofloral Turkish honeys and the effect of their consumption on glucose metabolism*

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Background/aim: Clinical trials have shown that low glycemic index (GI) nutrition reduces mean blood glucose concentrations and insulin secretions. The aim of the present study was to determine the GI values of various monofloral (citrus, milk-vetch, chestnut, thyme, lime, pine) honeys of Turkey, and the effect of their consumption on glucose metabolism.

Materials and methods: Processing data from 20 healthy volunteers, GI values were determined from the glycemia values by using the incremental area method. Serum insulin and C-peptide levels were also measured before and 120 min after the test.

Results: The GI values of citrus, thyme, lime, chestnut, pine, and milk-vetch honeys were found to be 44.9, 52.6, 55.3, 55.5, 58.8, and 69, respectively. Serum insulin and C-peptide values after honey consumption were relatively lower than those after reference food (glucose) consumption. By the end of the 120 min, serum insulin levels were significantly higher, while a significant decrease was observed after the consumption of chestnut honey ($P < 0.05$).

Conclusion: Citrus and thyme honeys were determined to have low GI, while serum insulin levels were significantly lower after the consumption of chestnut honey. Long-term research is needed to compare the effects of honey consumption on healthy and diabetic individuals.

Key words: Honey, glycemic index, glucose metabolism, nutrition

1. Introduction

It is important that a healthy diet includes proper and well-balanced nutrition. In patients with diabetes, which is rapidly becoming one of the major causes of premature illness and death worldwide, there is confusion about carbohydrates as the single most important source of food energy. The World Health Organization estimates that 347 million people worldwide have diabetes and projects that diabetes deaths will be the 7th leading cause of death in 2030 (1). The rate of increase of diabetes in Turkey is greater than the rates in the rest of Europe (2). Diabetes mellitus is the fifth leading cause of mortality in the country and, according to the results of Turkey's diabetes, hypertension, obesity, and endocrinology diseases prevalence study (TURDEP-II), the prevalence of type 2 diabetes in the country is 13.7% (2,3). The financial cost of diabetes in Turkey has increased by 40% over the last 15 years, with the main cause of this rapid increase being lifestyle changes, including those related to nutrition (2,3).

Some indices of carbohydrates based on their physiologic functions have been proposed. One well-established index is the glycemic index (GI), which can be used to classify foods based on their blood glucose-raising potential. The GI classification system in common use categorizes foods into 3 groups, as low (<55), medium (55–69) or high GI (>70). Clinical trials (4) in normal and diabetic subjects show that low-GI diets reduce mean blood glucose concentrations and insulin secretions. Therefore, compared with high-GI diets, low-GI diets offer a good means of reducing the rapidly increasing rates of diabetes in many countries (4). An international report on carbohydrates in human nutrition suggests that the concept of GI provides a useful means of selecting the most appropriate carbohydrate-containing foods for the

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maintenance of health and the treatment of several disease states like diabetes (4).

Honey has been a preferred healthy natural product and a valuable foodstuff since ancient times. Traditionally, honey has been consumed in Turkey to enhance health and to treat a number of different diseases; it is used by all age groups, from children to the elderly. However, "Is honey allowed for diabetic patients?" is a question frequently addressed to healthcare professionals in clinical practice.

Carbohydrates are very important nutrients in honey. Honey contains 25 different oligosaccharides, in addition to the main polysaccharides, glucose and fructose. The flora of the region in which honey is produced can significantly affect its properties such as color, taste, aroma, and the chemical composition of honey, which varies according to the nectar (5,6). The content of honey, especially the level of carbohydrates, varies according to the botanical origin (5,6).

The International Tables of Glycemic Index list honey as having a GI of 32 to 87, depending on botanical origin and fructose content (7). It is known that unifloral honeys have varying fructose content and fructose/glucose ratios. Furthermore, a study has shown that honey produces an attenuated postprandial glycemic response when compared with sucrose in both patients with diabetes and healthy individuals (8).

Turkey is one of the world's largest producers of honey. It has a wide range of honeys, which are defined according to both their botanical and geographical origin due to the many varieties of flora, ecological differences, and biological varieties. However, no study has been carried out to determine their GI values and their effect on glucose metabolism. Therefore, the current study was conducted to determine and classify the GI values of 6 different monofloral honey samples, all of which are produced nationwide, and to determine the changes observed in serum glucose, insulin, and C-peptide levels before and after the consumption of these honeys.

2. Materials and methods

2.1. Honey samples

The honey samples selected for analysis in the present study were collected from 6 different regions (Bursa, Muğla, Kayseri, Zonguldak, Aydın, and Mersin). The monofloral honey samples used in the current study were collected in a filtered form from beekeepers in 2012, with at least 5 samples collected from each of the 6 monofloral honey varieties (citrus, milk-vetch, chestnut, thyme, lime, and pine honeys), upon which pollen analysis was carried out. The pollen in each area was analyzed using a Nikon E 200 light microscope. Honeys containing 45% or more pollen were deemed to be "monofloral", and those containing the most predominant pollen of most of the plants were included in the study. Each honey sample was tested on at least 15 volunteers and the reference food was tested twice.

2.2. Study group

The present study was initiated with approval by the Erciyes University Clinical Research Ethics Committee as the Institutional Review Board dated 07.08.2012, number 212/564. The study group was composed of 20 healthy students with a mean age of 20.8 ± 1.8 years and enrolled at Erciyes University. The study inclusion criteria were: BMI < 25, no regular drug use, absence of food allergies, absence of family history of diabetes, absence of any known disease, and not being on a special diet. All volunteers were informed about the nature of the study, and after obtaining informed consent their data were recorded and blood samples were obtained. In terms of sample size, the presence of 10 individuals in each group had a power of 80% to test a difference at a P level of 0.05; this was an acceptable size for GI investigations (9).

2.3. Determination of GI

The participants were instructed to include a daily intake of 300 g of carbohydrates in their diet and to avoid excessive exercise on the day before the test. All participants fasted for 10–12 h before the test. Each participant was given 50 g of pure glucose as the reference food twice in different weeks, while portions of honey carbohydrates were given as a test food 5 times in different weeks. The first blood sample of the participants was taken from the capillary vessels of the finger using an automatic lancet (Safe-T-Pro, Germany). The participants then consumed 50 g of the reference food or a honey equivalent to 50 g of carbohydrates with 250 mL of water. Blood samples were taken in a similar manner at 15, 30, 45, 60, 90, and 120 min, and the amounts of blood glucose found in the obtained blood samples were recorded. The incremental area method was employed to determine GI values. The honeys were classified as having low, medium, or high GI. The honeys with GI values below 55% were defined as having low GI, GI values between 55% and 69% were defined as medium, and those with GI values above 70% were defined as high GI (10–13).

2.4. Determination of biochemical parameters

Venous blood samples were taken from all individuals for biochemical analysis before and after the test. The biochemical analyses were performed in the Central Laboratory of Gevher Nesibe Medical Faculty Hospital at Erciyes University. Glucose levels were determined using the spectrophotometrical method in an Abbott Architect C 800 autoanalyzer (ISE rate of 400 tests/h) (Abbott Laboratories, Turkey). Insulin and C-peptide levels were measured using an Immulite 2000 XPi Immunoassay system (200 tests/h) (Siemens Healthcare, USA) and with compatible kits.

2.5. Statistical analysis

All of the data obtained during the study were assessed using SPSS 16.0 under the supervision of academicians from Erciyes University, Faculty of Medicine, Department of Biostatistics and Medical Informatics. The compatibility of the variables with the normal distribution was investigated using Shapiro–Wilk tests. As the GI values of the honeys had a normal distribution, descriptive analyses were given using the means and standard deviations. Significance tests were carried out to evaluate differences between the groups and correlation coefficients were determined between the GI values of the honeys and their glucose contents. Statistical significances were calculated using Pearson's test. $P < 0.05$ was considered significant.

3. Results

The highest percentages of pollens were measured in chestnut and thyme honeys (Table 1). The GI values of monofloral honeys ranged between 44.9 ± 15.0 and 69.1 ± 27.3 (Table 2) and none of the GI values of the studied monofloral honeys were found to be high. While citrus (44.9 ± 15.0) and thyme honeys (52.6 ± 20.1) were in the low-GI group, the GI values of the milk-vetch (69.1 ± 27.3), chestnut (55.5 ± 20.2), pine (58.8 ± 27.0), and lime (55.3 ± 18.4) honeys were found to be medium. The honey with the highest fructose content was citrus (36.9 %) and this variety also had the lowest GI. Serum glucose levels decreased 120 min after consumption of the honeys and the reference food compared with the initial values of those levels (Table 3). While no difference was found in serum insulin, C-peptide, and glucose levels before the consumption of honey or the reference food, the serum insulin and C-peptide values in all honey-administered subjects after consumption were found to be lower than those in the reference food-administered subjects. Serum insulin levels increased after reference food consumption, and this increase was significant, especially after the consumption of the second reference food ($P < 0.05$). While a decrease in serum insulin levels was observed after the consumption of chestnut, lime, and thyme honeys, only the decrease that occurred following the consumption of chestnut honey was significant ($P < 0.05$). Honey consumption caused no significant differences in C-peptide levels ($P > 0.05$). However, the increase observed following reference food consumption was quite prominent and it was higher than all of the values obtained following honey consumption ($P < 0.05$) (Table 3). All 6 monofloral honey samples demonstrated similar blood-glucose curves, and all samples (including glucose) had a mean blood-glucose level peak at 30 min (Figure).

Table 1. Geographical and botanical origins of monofloral honey samples and predominant pollen rates (%).

Geographical origin	Botanical origin	Predominant pollen (%)
Mersin	*Citrus* spp. (citrus)	71.5
Kayseri	*Astragalus* spp. (milk-vetch)	60.39
Bursa	*Castanea* spp. (chestnut)	93.60
Aydın	*Thyme* spp. (thyme)	92.18
Zonguldak	*Tilia* spp. (lime)	46.8
Muğla	*Pinus* spp. (pine, honeydew)	>3 HDE

Table 2. Glycemic index (GI) values and GI classification of honeys.

Honey types	GI values ± SD	Minimum	Maximum	GI classification
Citrus honey	44.9 ± 15.0	14.3	72.3	Low
Milk-vetch honey	69.1 ± 27.3	25.2	109.0	Medium
Chestnut honey	55.5 ± 20.2	26.1	89.4	Medium
Thyme honey	52.6 ± 20.1	17.1	85.0	Low
Lime honey	55.3 ± 18.4	20.7	84.5	Medium
Pine honey	58.8 ± 27.0	30.1	103.4	Medium

* $P < 0.05$. Reference values: insulin: 2.6–29 µIU/mL; C-peptide: 0.9–7.1 ng/mL; glucose: 70–105 mg/dL.

Table 3. Serum biochemical analysis before and 120 min after intake of the reference food or the monofloral honey samples.

Parameters	Citrus honey		Milk-vetch honey		Chestnut honey		Thyme honey	
	pre	post	pre	post	pre	post	pre	post
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Glucose (mg/dL)	85.2 ± 11.6	77.8 ± 9.4*	78.2 ± 5.9	70.7 ± 8.2*	77.4 ± 5.4	72.5 ± 5.4	84.8 ± 6	75.5 ± 8.0*
Insulin (μIU/mL)	9.7 ± 7.9	10.2 ± 6.9	7.8 ± 5.4	9.4 ± 6.2	7.7 ± 4.3	5.5 ± 2.8*	10.6 ± 7.3	10.5 ± 6.1
C-peptide (ng/mL)	2.2 ± 1.6	2.1 ± 0.8	1.8 ± 0.6	2.0 ± 0.9	1.6 ± 0.5	1.6 ± 0.4	1.7 ± 0.7	1.9 ± 0.7
Parameters	Lime honey		Pine honey		Reference food; 1st test		Reference food; 2nd test	
	pre	post	pre	post	pre	post	pre	post
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Glucose (mg/dL)	76.1 ± 5	73.9 ± 4.4	82 ± 8.5	77.3 ± 6.2*	76.1 ± 4.8	65.7 ± 8.8*	80.5 ± 6.7	71.6 ± 11.9*
Insulin (μIU/mL)	7.8 ± 3.7	6.8 ± 3.3	6.8 ± 4.5	7.9 ± 3.2	7.7 ± 4.5	11.2 ± 10.0	7.8 ± 5.5	12.1 ± 7.1*
C-peptide (ng/mL)	1.6 ± 0.6	1.5 ± 0.5	2.2 ± 0.8	2.6 ± 1.1	1.8 ± 0.8	2.9 ± 2.2*	1.6 ± 0.8	2.9 ± 1.5*

* P < 0.05. Reference values: insulin: 2.6–29 μIU/mL; C-peptide: 0.9–7.1 ng/mL; glucose: 70–105 mg/dL.

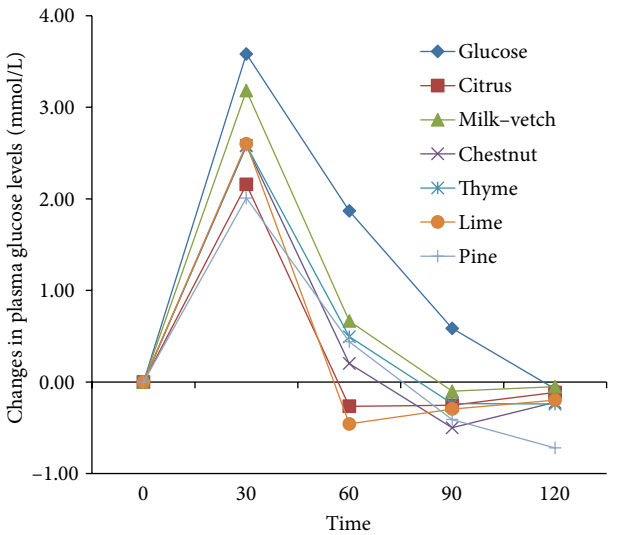

Figure. Changes in plasma glucose concentration after the reference food and the monofloral honey samples.

4. Discussion

GIs of many basic foods have been determined and International Tables of Glycemic Index have been published (14). However, it has been suggested that the GI of each food may vary from one region to another (15).

In the current study the citrus and thyme honeys fell in the low-GI group (<55), whereas the other tested monofloral honeys fell in the medium-GI group (55–69) (Table 2). There are several studies related to the determination of GI of honey in healthy individuals. The International Tables of Glycemic Index list honey as having a GI of 32 to 87 (7). The reason for this is that the chemical constituents of honey are not constant, and they vary according to botanical and geographical origins. Deibert et al. (15) determined the GI values for chestnut and lime honeys as 53.4 and 55.9, respectively; in the current study, these values were 55.5 and 55.3, respectively.

Studies have shown that fructose reduces hyperglycemia or glucose levels in rodent models of diabetes, healthy subjects, and diabetic patients (16–20). Evidence suggests that fructose consumption prolongs gastric emptying, which may slow down the rate of intestinal absorption (21,22). Besides that, fructose, which is an important component of honey, is known to cause a minimal stimulation of insulin secretion and a slow increase in blood glucose levels (23).

In a study in which natural honey, glucose, and simulated honey were compared, it was reported that natural honey modulated the physiological glycemic response with rebound recovery of plasma glucose levels (24). Yaghoobi et al. (25) showed that, compared with sucrose, healthy individuals who consumed natural honey for 30 days had lower fasting blood-glucose levels. In another study conducted on healthy volunteers, lower serum-glucose concentrations and glycemic response were recorded with honey than with a glucose-fructose solution (26). Agrawal et al. (27) reported that honey decreased the postprandial glycemic response in patients with glucose intolerance.

Oligosaccharides have modulatory effects on microbiota of the digestive system and systemic effects (20,28–30). Some studies reported that a diet based on Palatinose (isomaltulose), a disaccharide found in honey, suppressed postprandial hyperglycemia and had a beneficial effect on parameters related to metabolic syndrome (31).

Citrus honey had the highest fructose content (36.9%) of all the honeys in the current study; at 30 and 60 min after the consumption of citrus honey, which recorded the lowest GI, a lower increase was observed in blood-glucose levels when compared with other honeys and glucose. The fastest increase in blood glucose at these durations was observed in the reference food and in milk-vetch honey, which had a higher GI (Figure).

In one study honey caused a higher C-peptide increase than comparable amounts of sucrose or glucose (8), while in another study, it was found that lime honey caused a lower C-peptide increase than comparable amounts of a fructose/glucose mixture (28). It should be noted that there are differences in the results of studies related to the effects of honey on serum insulin and C-peptide levels. Watford et al. (28) stated that very small amounts of fructose, which is the main component of honey, could increase hepatic glucose uptake and glycogen storage, as well as reduce peripheral glycemia, and thus insulin levels. Fructose ingestion or fructose-enriched meals markedly reduced plasma glucose and serum insulin in healthy, impaired glucose-tolerant, overweight, obese, and type 1 and type 2 diabetic subjects (17,18,30–33). In another study, it was found that honey significantly decreased the serum glucose concentration and C-peptide and insulin levels in healthy individuals when compared with a glucose-fructose solution that was prepared at the same ratio (34). In healthy subjects, compared with dextrose, honey supplementation was shown to elicit lower increments in serum insulin and C-peptide levels (34). Elliott et al. (35) found that honey intake caused a significant lowering of plasma insulin and C-peptide in normal subjects when compared with sucrose and dextrose intake; they related their findings to the fructose content of honey.

In the current study, by the end of the 120 min after the consumption of glucose (the reference food), serum insulin and C-peptide levels were still significantly high, while honey consumption caused no such significant difference in C-peptide levels ($P > 0.05$). Moreover, following the consumption of chestnut ($P < 0.05$), lime ($P > 0.05$), and thyme ($P > 0.05$) honeys, serum insulin levels decreased (Table 3).

It can be said that the high fructose content and the combined presence of glucose and fructose in monofloral honeys produced in Turkey, as used in the current study, facilitate fructose absorption and have a positive effect on serum insulin and C-peptide levels.

In conclusion, in the present study the GI values of the tested monofloral honeys from Turkey were determined to be low or medium. According to these results and the results of almost all previous studies, it is recommended that diabetic patients should consume honey rather than glucose. The diabetic diet is strictly controlled in terms of carbohydrates, and therefore individuals with diabetes and impaired glucose tolerance should prefer types of honey with a low GI in their nutrition. Citrus honey and thyme honey were determined to have a low GI. Additionally, it is interesting that serum insulin levels were determined to be significantly low 2 h after chestnut honey consumption, while a significant increase was observed after reference food consumption.

To the best knowledge of the authors, there has not been any previous report related to the GI determination of different Turkish honeys. Long-term research is needed to evaluate in detail the metabolic effects of different types of honey with different GIs on healthy and diabetic individuals.

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