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Processed and Unprocessed Honey: A Comparative Study on the Effect of Honey on Blood Sugar Levels in Diabetics

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Abstract

Background: Honey is a natural sweetener that has been used for hundreds of years for its nutritional and medicinal properties, but the impact of unprocessed versus processed honey on blood glucose levels in diabetics is subject to debate. This study aimed to assess the impact of processed and unprocessed honey on blood sugar levels in diabetics.

Methods: This randomized, double-masked clinical trial included 90 diabetic patients. The patients consumed 30 g of both unprocessed and processed honey, and blood samples were collected before and after the consumption of each honey type to measure the blood glucose levels. Laboratory factors of honey, such as sugar before hydrolysis, proline, and fructose to glucose ratio (F/G), hydroxymethylfurfural (HMF), and sucrose content, were also analyzed.

Results: The results showed that unprocessed honey had a more substantial effect on blood glucose levels compared to processed honey, but the difference was not significant ($P<0.07$). The glucose levels were 241.2 ± 72.4 after ingesting unprocessed honey and 197.7 ± 53.3 after ingesting processed honey. There was no correlation between the laboratory factors of honey and the blood glucose levels.

Conclusion: Unprocessed honey had a more detrimental impact on blood glucose levels in diabetics than processed honey, and the laboratory factors of honey did not have a significant impact on the glycemic reaction. Consequently, diabetics have to abstain from eating unprocessed honey and restrict their intake of processed honey. The implications and mechanisms involved in the effect of honey on blood sugar levels require further research.

Keywords: Honey, Blood glucose, Type 2 diabetes, Fructose, Sucrose

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Introduction

A naturally occurring sweetener, honey contains different concentrations of sugars, vitamins, minerals, antioxidants, and enzymes. With its lower glycemic index, it increases blood sugar at a slower rate than sugar (1). Honey can have different colors, flavors, and textures depending on where the bees get their nectar, what kind of bees they are, what season it is, and how the honey is processed (2). The difference between processed and unprocessed honey is precisely how they are processed. Raw honey is unprocessed and unfiltered. The honey extracted from the honeycomb is immediately packaged (3). In contrast, regular honey is filtered and pasteurized to kill any yeast cells and extend its shelf life (4). Unprocessed honey incorporates herbal substances, including bee pollen, bee propolis, vitamins, minerals, enzymes, amino acids, and antioxidants (5, 6). Unprocessed honey may also contain impurities, along with beeswax and pollen, which could have an effect on its taste and appearance (7). Honey is a natural sweetener that consists of several sugars, including maltose, fructose, glucose, and sucrose. These sugars can affect the pattern of insulin secretion, depending on the kind and quantity of honey consumed.

According to the Centers for Disease Control (CDC), approximately 1 in 10 people have diabetes, and about 1 in 5 of them are unaware of it. The prevalence of diabetes varies by age, race, and ethnicity (8). The International Diabetes Federation (IDF) reported that the prevalence of diabetes in adults in Iran was 9.5% in 2021, equivalent to 5.45 million cases. The IDF also predicts that this number

will rise to 8.9 million by 2045 (9). In one study, the prevalence of diabetes was reported as 16.1%, and 4.8% of those affected were not aware of their disease. This study also determined that the prevalence of pre-diabetes was 25.8%, and that 58.3% of people with diabetes were not properly managed (10).

A review of published literature reported that the prevalence of diabetes in Iran increased from 6.7% in 2000 to 11.9% in 2011, and that the incidence of type 1 diabetes increased from 4.8 per 100,000 person-years in 2000 to 6.5 per 100,000 person-years in 2016 (9). Another study reported that the prevalence of impaired fasting glucose was 16.8% (11). Abdulrhman et al studied 30 controls without diabetes and 50 patients with type 1 diabetes mellitus in their case-control cross-sectional study. All subjects underwent oral sugar tolerance tests using honey, sucrose, and glucose in three sittings, and postprandial and fasting serum C-peptide levels were measured. For each of the three trials, the peak incremental index (PII) and glycemic index (GI) were calculated. Lower PII and GI levels were observed after honey consumption compared to sucrose in both cases and controls ($P<0.01$). Additionally, in both groups, honey consumption led to a significant increase in C-peptide levels compared to glucose and sucrose ($P<0.01$)(12). Another study tested the impact of honey consumed simultaneously with antidiabetic drugs (metformin or glibenclamide) in diabetic rats. The study found that honey improved glycemic control, increased insulin levels, strengthened antioxidant defenses, and reduced oxidative damage in rats. The study suggested that honey is probably useful as an adjunct to standard diabetes therapy, partially because of its antioxidant properties (13).

Amid the myriad of herbal sweeteners available, honey has garnered attention not only for its perceived health benefits but additionally for its potential implications in glucose metabolism. Even as honey is often lauded for its antioxidant properties and use in conventional medicine, the complex relationship between honey consumption and glycemic reaction in diabetic individuals remains a subject of medical inquiry. This study aimed to contribute to the present body of knowledge by investigating the impact of unprocessed honey on blood glucose levels in people with diabetes. Given the limited and, at times, conflicting evidence on this subject, a comprehensive exploration of the glycemic effects of honey, with a particular focus on unprocessed honey, is vital. Information on the nuances of honey's effect on glycemic control in diabetic populations has implications for dietary recommendations. It can contribute to refining the techniques for managing blood glucose levels in these people. The study's findings aim to inform healthcare professionals, researchers, and individuals managing diabetes about how consuming honey can potentially affect blood glucose levels. Additionally, the present study seeks to contribute to the ongoing discussion on dietary strategies for glycemic control in diabetic populations.

Methods

Honey Experiments (in Vitro)

In this study, natural, unprocessed, and processed honey from three brands were evaluated based on their laboratory factors. Chemical tests were performed on the honey at the Arak University of Medical Sciences Food and Drug Control Laboratory, and the samples were then stored at room temperature for the study.

Measuring Reducing Sugars Before Hydrolysis

In order to determine the amounts of sugars that can be oxidized before breaking them down, a solution of one gram of honey in 250 mL of pure water was prepared. The Fehling test was used to measure how much sugar could be oxidized. The formula used to calculate the percentage of this type of sugar was[14]:

$$S=\frac{F\times 250\times 100}{V\times W\times 1000}\,S=\frac{F\times 250\times 100}{V\times W\times 1000}$$

where S was the percentage of reducing sugars in the honey sample, F was Fehling's standard value, V was the volume of Burt's solution used in mL, W was the mass of the honey sample in g, and the conversion factor was 1000.

Measurement of Reducing Sugars after Hydrolysis

First, 2 mL of strong hydrochloric acid was added to 50 mL of the sample solution in a 250 mL flask. Then, the solution was neutralized with strong sodium hydroxide, and phenolphthalein was used as an indicator to confirm neutralization (light purple color). The amount of sugar after sugar breakdown (S1) was found using this formula (14):

$$S_1=\frac{F\times 250\times 100\times 100}{W\times V\times 50\times 1000}\,S_1=\frac{F\times 250\times 100\times 100}{W\times V\times 50\times 1000}$$

Calculating the Percentage of Sucrose

This equation was used to calculate the percentage of sucrose:

$$N=(S1-S)\times 0.95\%\ \text{sucrose}$$

Measurement of the Fructose to Glucose Ratio (F/G Ratio)

First, 25 mL of the solution was transferred to a 250 mL flask. Iodine and sulfuric acid were added, and then the solution was titrated with 0.1% sodium thiosulfate using a starch indicator. The titration was continued until the solution turned clear. The formula used to find out the percentage of glucose was (14):

$$\text{Glucose percentage (GP)}=\frac{200\times 9.01\times D\times 100}{25\times W\times 1000}=\frac{200\times 9.01\times D\times 100}{25\times W\times 1000}$$

where D was the difference between the sodium

thiosulfate consumed by the real sample and the blank sample, and *W* was the honey sample weight in grams.

The formula used to calculate the fructose percentage was (14):

Fructose percentage = amount of reducing sugars before hydrolysis - the amount of glucose

Measurement of Hydroxymethylfurfural

HMF is an organic compound formed from the breakdown of sugars in honey, particularly when it is heated or stored for long periods. It is also associated with potential health risks if consumed in large amounts. A solution of 5 gr of honey and 25 mL of water was made. Two drops of ethanol and 5 mL of sodium bisulfite were added to prevent hydroxymethylfurfural from affecting the light absorption. The absorbance was measured at 284 nm and 336 nm using a 10 mm quartz cell. The formula used to calculate the amount of hydroxymethylfurfural was (15):

$$149.7 = \frac{126 \times 1000 \times 1000}{16830 \times 10 \times W} \quad HMF = (A_{284} - A_{336}) \times 149.7 \times 5 \times \frac{D}{w} \quad 149.7 = \frac{126 \times 1000 \times 1000}{16830 \times 10 \times W}$$

$$HMF = (A_{284} - A_{336}) \times 149.7 \times 5 \times \frac{D}{w}$$

where,

149.7: Factor to convert absorbance to concentration

16830: Molar absorbance of hydroxymethylfurfural at 284 nm

126: Molecular weight of hydroxymethylfurfural

1000: Converts Kg/g to g/mg

W: Weight of honey in g

D: Dilution factor

Measurement of Proline

A solution of 5 gr of honey and 50 mL of water was made. In another tube, 0.5 mL of proline solution was added. Then, 1 mL of ninhydrin solution and 1 mL of formic acid were added to both tubes. The tubes were heated in a water bath at 90 °C for 10 minutes. The blank tube was used as a reference, and the absorbance of the tubes was measured between 500 and 520 nm. Optimal absorption was at 510 nm. The formula used (16) to do the calculation was (16):

$$\frac{E_p}{E_s} \times \frac{M_1}{M_2} \times 80 w_p \quad \frac{E_p}{E_s} \times \frac{M_1}{M_2} \times 80 w_p$$

where

Ep: Absorption of sample solution

Es: Absorption of proline standard solution

M1: The original mass of proline in the standard solution (here, 40 mg)

M2: The main mass of the honey sample (here, 5 grams)

80: Dilution factor per gram of honey

Experimental Design

The study participants were 90 diabetic patients with type 2 diabetes who were admitted to Imam Reza Clinic (Arak, Iran). Subjects aged 18–60 years, of any gender and any BMI, with no history or current diagnosis of cancer, no acute or emergency conditions, no psychiatric disorders (such as personality disorders), and no major surgeries (such as gastrectomy, pancreatectomy, liver or kidney transplant, or colectomy) were included. Females could not be pregnant or breastfeeding and the subjects could not be using insulin to control diabetes. The exclusion criteria were acute illness, hospitalization, or medication dose change during the study. The participants' diet and physical activity were also monitored throughout the study.

Study Design

This study was a double-masked, randomized controlled trial. The participants were randomly assigned to six groups: Group D received unprocessed honey, groups A, B, and C received processed honey from different brands, group E, as a negative control, received drinking water, and group F, as the positive control group, consumed fructose syrup. The participants were not asked to change their usual diet, but they were matched in terms of nutritional conditions, age and gender, medication usage, and disease history. Fasting blood glucose (FBS) and weight were measured before the study. Weight was measured and recorded to the nearest 100 grams with minimal clothing using a mechanical column scale (Seca). FBS was measured using a digital blood glucose meter.

Blood sugar was measured as fasting blood sugar (FBS) and again 30 minutes after consumption. The blood glucose profiles of the participants were compared based on the consumption of fructose syrup, processed honey, and unprocessed honey.

Statistical Methods

Data are presented as mean ± SE and were analyzed by paired *t*-test and one-way ANOVA. The correlation was evaluated by Spearman's rank. The Wilcoxon test was used to examine the change in blood glucose levels before and after consuming processed honey (A, B, and C) and unprocessed honey (D) in different groups. Each group consisted of 15 patients. The Wilcoxon test was employed to assess the significance of differences compared to the baseline in each group. *P* values smaller than 0.05 were considered significant.

Results

This study included 90 participants (58 female and 32 male) with type II diabetes. Table 1 shows the demographic characteristics of the participants, and Table 2 shows the chemical composition of the four types of honey we used in the study.

Figure 1 shows the results of the Wilcoxon test comparing blood glucose levels before and after consuming processed honey (samples A, B, and C) and unprocessed

Table 1. Demographic characteristics of the participants

	Mean ± SD			Min			Max			Range		
	Female	Male	Total	Female	Male	Total	Female	Male	Total	Female	Male	Total
Age	54.1 ± 6.4	53.4 ± 6.8	53.89 ± 0.6	39	35	35	61	60	61	22	25	326
Weight	76.4 ± 13.3	81.03 ± 0.0	78.03 ± 1.3	57	60	57	118	108	118	61	48	61
Height	160.6 ± 4.1	174.5 ± 11	165.52 ± 0.8	154	160	154	157	187	187	21	27	33
BMI	29.2 ± 4.2	26.9 ± 4.5	28.45 ± 4.4	24.1	19.8	19.8	41.9	41.8	41.9	17.8	22	22.10
Year	8.2 ± 5.4	6.4 ± 6.6	7.62 ± 0.5	1	0	0	25	16	25	24	16	25
FBS	226.5 ± 80.7	238.8 ± 63.7	230.7 ± 7.8	114	129	114	440	376	440	326	247	326

Table 2. The chemical factors of different types of honey

Compound	A	B	C	D
Sugar before hydrolysis	62.5	66.9	61.4	69.4
Sucrose	11.8	5.9	9.7	0.7
HMF	38.2	38.2	61	14.2
F/G	0.7	1.4	0.9	1.9
Proline	242.6	188	211.7	350.3

A, B, C: processed honey
D: unprocessed honey

Table 3. Comparison of blood sugar levels in patients before and after consumption of different types of honey

Groups	Status	Mean ± SD	Min	Max	Sig.
A	FBS	196.06 ± 44.4	129	267	0.6
	30 min	197.7 ± 53.3	123	298	
B	FBS	182.06 ± 26.3	218	129	0.13
	30 min	193.6 ± 41.6	279	135	
C	FBS	186.5 ± 44.2	115	261	0.006
	30 min	207.8 ± 60.4	136	341	
D	FBS	225.9 ± 63	116	356	0.2
	30 min	241.2 ± 72.4	127	420	
Syrup	FBS	287.3 ± 70.5	114	376	0.07
	30 min	309.06 ± 86.9	117	438	
Drinking Water	FBS	309.6 ± 80	162	440	0.01
	30 min	282.1 ± 94	156	432	

honey (sample D) in different groups. We also measured the blood sugar levels in each group after consuming the honey ($\lambda = 24.29$ and Sig. = 0.000). The group that consumed fructose syrup had the highest average rank of blood sugar (68.20), and the group that consumed brand B had the lowest (31.81).

The result of Table 3 showed that brand "A" honey caused the smallest rise in blood glucose, and unprocessed honey caused the biggest rise. Table 4 shows how the factors we measured in honey were related to blood glucose levels.

The correlation coefficient between the pairs of variables in the laboratory shows that they had a negative and insignificant relationship with blood sugar levels.

Discussion

The findings of this study indicated that unprocessed honey can increase blood sugar levels in diabetic patients, as suggested by natural sugars and potentially active enzymes in unprocessed honey. The observed increase in blood sugar could be attributed to the presence of natural sugars and potentially active enzymes in unprocessed honey (17). This increase in blood sugar is important in diabetic patients.

Table 4. The correlation of different laboratory factors of honey

	Mean ± SD	Correlation	Sig.
Sugar before hydrolysis	65.07	-0.172	0.59
Sucrose	7.06	0.189	0.55
HMF	37.9	-0.053	0.87
F/G	1.2	-0.203	0.52
Proline	255.8	-0.163	0.61

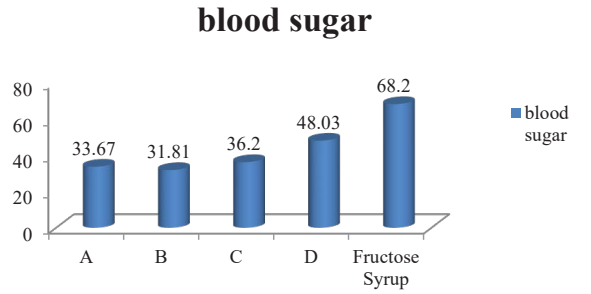

Figure 1. Comparison of mean blood sugar ranks among groups

The mean ± SE duration of diabetes in this study was 7.62 ± 0.5 years, 8.2 ± 5.4 years for women, and 6.4 ± 6.6 years for men. In this double-masked clinical trial, we found that consuming honey did not improve the blood sugar of type 2 diabetic patients. It was observed that unprocessed honey raised blood glucose more than processed honey. The results also showed that sugar before hydrolysis, proline, and the F/G ratio were higher in unprocessed honey than in processed honey. However, the sucrose content in unprocessed honey was lower than that of other components. Glucose and fructose are two types of sugars that affect blood sugar and insulin levels differently. Sucrose, as a disaccharide, requires enzymatic hydrolysis into its constituent monosaccharides, glucose and fructose, prior to intestinal absorption. The comparatively low sucrose concentration observed in raw honey suggests extensive enzymatic conversion of

sucrose to glucose and fructose during natural ripening. In contrast, thermal processing of honey denatures these enzymes, resulting in higher residual sucrose content. As monosaccharides, glucose and fructose are directly bioavailable and rapidly absorbed into the bloodstream, eliciting a prompt glycemic response. Conversely, sucrose must first undergo hydrolysis within the intestine, thereby delaying its glycemic impact (18). Consequently, the compositional profile of unprocessed honey facilitates a more rapid and pronounced elevation in blood glucose compared to processed honey, which retains higher sucrose levels.

In standard honey, the fructose to glucose ratio should be 0.9 or less (14). The higher this ratio, the lower the blood sugar effect of honey, because fructose is absorbed slowly in the intestine and has to be changed to glucose in the liver before entering the bloodstream. Therefore, we expected that a higher fructose intake would result in a smaller increase in blood glucose levels (19). However, in our study, unprocessed honey had a higher fructose to glucose ratio than the standard limit (1.9) and also caused a bigger increase in blood sugar in patients. Fructose is absorbed and used differently from glucose. Fructose does not make the pancreas release insulin, so it does not increase blood sugar as much as glucose (20). Kwon et al reported that fructose was better for blood sugar control than sucrose, and that less fructose was better than more (20). Also, Deibert et al reported that the blood sugar and insulin response depended on the fructose content of honey (21). However, in the study by Ischayek et al there was no significant difference among different types of honey in terms of fructose to glucose ratio (22).

In the present study, the increase in blood sugar was compared after the consumption of different honey brands. It was observed that brand B, with sugar content before hydrolysis, sucrose, HMF, fructose-to-glucose ratio, and proline levels of 66.9, 5.9, 38.2, 1.4, and 188, respectively, had the least impact on increasing blood sugar (Figure 1). The greatest increase, after fructose syrup, was related to unprocessed honey. Thus, the fructose content or other components in the honey may have affected the results of this study. OO Erejuwa et al showed that fructose had a positive effect on blood sugar control, hormones related to glucose and appetite, body weight, food intake, carbohydrate oxidation, and energy expenditure (23). Another study reported that proline, an amino acid, was higher in the blood of diabetic patients and suggested that adding or reducing proline supplements in diabetic diets could help regulate blood sugar and blood lipids (24). However, in our study, we found a weak and negative correlation between proline and the level of blood glucose and honey indices. The other indices also had a negative relationship with blood sugar.

Also, insulin secretion can be increased by reducing inflammation and oxidative stress in pancreatic beta cells, which otherwise can damage these cells and impair their function (25). Honey influences hormones that regulate glucose metabolism, such as GLP-1 and GIP, by activating their receptors or altering the gut microbiota (26), and the effects depend on the honey type, with a lower glycemic index and higher antioxidant levels present in raw honey compared to processed honey (25). The findings align with existing literature highlighting the importance of scrutinizing the glycemic response to natural sweeteners in diabetic populations. The intricate interplay between honey's constituents and the physiological response in individuals with diabetes underscores the need for nuanced dietary recommendations.

This study had limitations. The inherent variability in honey compositions, individual dietary habits, and the heterogeneity in diabetic phenotypes within the study cohort may have introduced confounding factors. The sample size was relatively small, and glycemic control was not assessed long-term, so the results should be interpreted with caution.

Determining the impact of each component of unprocessed honey on the observed glycemic effects requires further research. Given the wide variety of honey, widespread studies are needed to scrutinize the link between the constituents of honey and the status of blood glucose in diabetic patients.

Conclusion

The findings of this study are valuable for understanding the effect of honey on blood glucose levels in diabetic patients. The findings emphasize the need for a technique for diabetic dietary recommendations considering the unique glycemic reaction related to unprocessed honey. Although honey is traditionally perceived as a natural sweetener with health-promoting properties, its implications for glycemic control must be carefully considered in the context of diabetes. Healthcare professionals must incorporate these findings into their counseling practices, advising diabetics to be vigilant about honey consumption, in particular while choosing unprocessed varieties. This review contributes to the expanding body of literature examining the complex relationship between dietary choices and glycemic effects in people with diabetes. Although honey is known for its potential health benefits, including its antioxidant properties, it is important to consider its effects on blood sugar levels, especially in diabetic patients, to ensure it does not cause harmful fluctuations. In addition, this research focuses on explaining the mechanisms behind the determined results and making clear recommendations for the consumption of honey for diabetics.

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Authors' Contribution

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Competing Interests

The authors declare that they have no conflict of interest.

Ethical Approval

This study protocol was supported and approved by the Ethics Committee of Arak University of Medical Sciences (IR.ARAKMU.REC.1399.291). The study was registered with the IRCT code IRCT20210125050135N1.

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