Original Article

Evaluation of therapeutic potential of Arhar honey (*Cajanus cajan*) in subjects with impaired glucose tolerance

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Abstract

Background: In Indian Medicine System, Arhar honey is believed as one of the valuable medicinal foods. Honey is being used since ancient times owing to its functional properties and nutritive value.

Aims: We aimed to evaluate the effect of honey supplementation on fasting blood glucose (FBG) level and lipid profile of the subjects with impaired glucose tolerance (IGT) and healthy subjects.

Methods: The selection of subjects was done through oral glucose tolerance test (World Health Organization/Food and Agriculture Organization, 1998). On the basis of blood glucose level, 28 subjects were selected by purposive random sampling and were divided into two groups. Group I included normal healthy subjects having FBG in the range of 70–100 mg/dl ($n = 14$), and Group II was comprised of subjects having FBG level between 100 and 125 mg/dl falling in the category of IGT ($n = 14$). 70 g honey was administered to subjects in both the groups on an empty stomach for 60 days and its effect on body weight, body mass index (BMI), blood pressure, FBG, glycated hemoglobin (HbA1c), and lipid profile was observed.

Results: Honey administration lowered blood glucose levels and lipid levels in subjects with IGT and normal healthy subjects. Other benefits of honey administration include an increase in high-density lipoprotein cholesterol levels and a reduction in BMI.

Conclusion: Consumption of honey has shown a reduction in body weight, BMI, FBG, HbA1c, and improvement in lipid profile in IGT subjects.

Keywords: Honey consumption, impaired glucose tolerance, metabolic profile

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INTRODUCTION

Among the available sweeteners, honey was probably the first discovered by humanity. The use of natural honey as a complementary and alternative medicine is well known for various disorders.[1] Honey is high in carbohydrate. Its glycemic index (GI) varies from 32 to 85 depending on the botanical source. Honey also contains a small amount of proteins, enzymes, amino acids, minerals, trace elements, vitamins, aroma compounds, and polyphenols.[2]

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Evaluating the effect of honey consumption on glucose regulation was a matter of interest for decades. Agrawal *et al*. reported that subjects with reduced glucose tolerance or mild diabetes who were subjected to the World Health Organization (WHO)-recommended oral glucose tolerance test (OGTT) on the 1st day followed by oral honey tolerance test the next day exhibited a higher tolerance to honey, suggesting that honey could be an alternative to sugar for the subjects with metabolic pathologies.[3] It is important to take

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into account the ability of carbohydrate-rich foods to influence the postprandial glucose load in nondiabetic subjects. Different studies reveal the hypoglycemic effect of honey, but the mechanism of this effect remains unclear. It was suggested that fructose, selective mineral ions (selenium, zinc, copper, and vanadium), phenolic acids, and flavonoids might have a role in the process.[4]

Prediabetes (impaired glucose tolerance [IGT]) is considered the precursor of progression to diabetes. In IGT stage, glucose levels are higher than the normal glucose values, indicating that an individual with prediabetes has not yet become a diabetic.[5]

As subjects with prediabetes have an increased risk of type 2 diabetes, monitoring the prevalence and incidence of diabetes and other associated disorders becomes important. We hypothesized that honey might have potential to modulate body mass index (BMI) values, fasting blood glucose (FBG), glycated hemoglobin (HbA1c), and lipid profile of healthy subjects and subjects having IGT. The present study was planned to evaluate and compare the efficacy of honey supplementation in healthy subjects as well as subjects having IGT.

METHODS

The study was conducted at the School of Studies in Biochemistry, Jiwaji University, Gwalior, from 2010 to 2013 where a diabetes clinic is run every weekend. Subjects were screened by performing OGTT and divided into two groups. All the subjects were briefed about the purpose of the study. A fasting blood sample was collected and each subject was administered with 75 g glucose dissolved in 300 ml of water and blood glucose levels were monitored at 30-min intervals for 2 h (by Finger Prick Accu-Chek Roche Diagnostics India Pvt. Ltd., Mumbai, Maharashtra, India) and blood glucose curves were plotted for reference food (glucose).[6,7] The selection of subjects was done through OGTT (WHO/Food and Agriculture Organization, 1998). On the basis of blood glucose level, 28 subjects were selected by purposive random sampling and were divided into two groups. Group I included normal healthy subjects having FBG in the range of 70–100 mg/dl ($n = 14$), and Group II was comprised of subjects having FBG level between 100 and 125 mg/dl falling in the category of IGT ($n = 14$). 70 g honey dissolved in 130 ml of water was administered to subjects in both the groups on an empty stomach for 60 days and its effect on body weight, BMI, blood pressure, FBG, HbA1c, and lipid profile was observed.

Supplementation of honey

Blood collection

All the 28 subjects were asked to attend the testing session for estimation of baseline biochemical parameters after 12-h overnight fast, and subjects were instructed not to consume unusually large meals or alcohol on the previous day and to avoid vigorous exercise, cycling, and walking before testing session. The blood sample was taken by vein puncture and collected in ethylenediaminetetraacetic acid with sodium fluoride tubes and then centrifuged at 4°C for 10 min at 2500 rpm. Plasma samples were stored at −20°C for further analysis.

Biochemical analyses

Estimation of FBG and lipid profile was done before and after the supplementation of honey. FBG was determined by glucose oxidase–peroxidase method.[8] HbA1c was determined using colorimetric method adopted by Nayak *et al*., 1981. Kit method (Crest Biosystems, a division of coral clinical systems) was used for determination of triglycerides (TGs) and high-density lipoprotein cholesterol (HDL-C). Very low-density lipoprotein (VLDL), low-density lipoprotein (LDL), and risk ratio were also calculated.[9,10]

Anthropometry

Anthropometric parameters (weight, waist/hip circumference, and BMI) and blood pressure of the subjects were measured and recorded at baseline and at the end of the study.

Determination of nutrients and physical properties of honey

Ash, moisture, nitrogen content, sucrose, total reducing sugar, glucose–fructose ratio, and phenol content were determined. Physical properties such as acidity, specific gravity, pH, and conductivity were also studied.

Chemicals and kits used

Kit method (Crest Biosystems, a division of coral clinical systems) was used for determination of TGs and HDL-C.

Statistical analysis

Statistics Program for Social Sciences (SPSS), IBM, USA, version 20.0 computer software package was used for all the analysis. Statistical analysis was performed by using a paired *t*-test. Significance level was assessed at 5%.

RESULTS

Honey supplementation resulted in a significant lowering of weight by 1.62% and 1.29% in males and females with a simultaneous decrease in BMI of males (1.63%) and females (1.34%), respectively [Table 1], in IGT group. A similar effect was observed in healthy subject group where weight and BMI was reduced by 1.84% and 1.5% in males and by 1.85% and 1.22% in females respectively.

A drop of 2.87% and 0.49% in FBG was noted in males and females of IGT group. HbA1c of female subjects in IGT group was significantly decreased by 2.34% after honey administration [Table 3]. FBG was lowered by 6.78% and 6.84% in males and females, respectively, with a significant decrease of 5.08% in HbA1c of normal healthy male subjects on honey supplementation [Table 4].

A decrement of 14.29% was noted in total cholesterol (TC) in females whereas male group indicated a reduction of 0.53% in IGT group. TG level was brought down by 16.13% in males and by 18.67% ($P < 0.05$) in females. LDL cholesterol (LDL-C) in male group was slightly increased (3.04%), and in female group, it was decreased by 23.18%. VLDL cholesterol in males was reduced by 6.13% and females showed a drop of 18.67% ($P < 0.05$). Risk ratio was decreased by 7.08% and 23.42% ($P < 0.002$) in males and females, respectively [Table 3], in IGT subjects.

Remarkable improvement of lipid profile was seen in normal subjects on honey supplementation. TC was reduced by 17.10% ($P < 0.005$) in males, and female group exhibited a reduction of 15.53% ($P < 0.05$). TG was lowered by 20.35% ($P < 0.10$) in

Table 1: Effect of honey supplementation on anthropometric measurements and blood pressure in impaired glucose tolerance subjects

Parameters	Male		Female		Percentage change (male)	Percentage change (female)
	Before	After	Before	After		
Weight	74.86±3.02	73.64±2.94**	66.57±2.33	65.71±2.60*	1.62↓	1.29↓
W/H ratio	0.96±0.02	0.96±0.02	0.88±0.02	0.88±0.02	0.08↓	0.31↑
BMI	25.89±0.67	25.47±0.63**	28.11±0.78	27.73±0.85*	1.63↓	1.34↓
SBP	127.14±4.74	127.14±5.22	114.57±5.34	120.00±3.09	0.00	4.74↑
DBP	81.43±4.04	81.43±2.61	75.71±3.69	77.14±1.84	0.00	1.89↑

*Significant change $P<0.05$, **Significant change $P<0.01$, ↑; Increase, ↓: Decrease. Data are expressed as mean±SE. W/H ratio: Waist–hip ratio, BMI: Body mass index, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, SE: Standard error

Table 2: Effect of honey supplementation on anthropometric measurements and blood pressure in normal healthy subjects

Parameters	Male		Female		Percentage change (male)	Percentage change (female)
	Before	After	Before	After		
Weight	69.71±4.14	68.43±3.97**	68.57±3.58	67.71±3.70*	1.84↓	1.5↓
W/H ratio	0.94±0.02	0.94±0.02	0.85±0.03	0.86±0.03	0.23↓	1.18↑
BMI	23.94±1.31	23.50±1.25**	27.35±1.03	27.02±1.12*	1.85↓	1.22↓
SBP	114.29±3.69	118.57±5.95	118.57±7.69	115.71±4.29	3.75↑	2.41↓
DBP	76.86±2.99	78.57±3.40	75.14±4.62	75.71±2.97	2.23↑	0.76↑

*Significant change $P<0.05$, **Significant change $P<0.01$. ↑; Increase, ↓: Decrease. Data are expressed as mean±SE. W/H ratio: Waist–hip ratio, BMI: Body mass index, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, SE: Standard error

Table 3: Effect of honey supplementation on fasting blood glucose, glycosylated hemoglobin level, and lipid profile in impaired glucose tolerance subjects

Parameters	Male		Female		Percentage change (male)	Percentage change (female)
	Before	After	Before	After		
FBG	97.97±3.16	95.16±2.60	94.2±2.04	93.7±2.32	2.87↓	0.49↓
HbA1c	5.43±0.44	5.11±0.33	5.1±0.06	5.0±0.08**	5.85↓	2.34↓
TC	146.06±8.83	145.30±9.37	166.2±10.16	142.4±15.98	0.53↓	14.29↓
TG	144.77±24.47	121.42±16.93	155.5±18.24	126.5±15.99*	16.13↓	18.67↓
HDL-C	35.43±3.47	36.85±2.37	38.0±2.19	42.6±2.73	4.02↑	11.96↑
VLDL-C	28.95±4.89	24.28±3.39	31.1±3.65	25.3±3.20*	16.13↓	18.67↓
LDL-C	81.68±7.45	84.16±9.08	97.0±11.97	74.5±14.74	3.04↑	23.18↓
Risk ratio	4.38±0.52	4.07±0.43	4.5±0.42	3.4±0.46**	7.08↓	23.42↓

*Significant change $P<0.05$, **Significant change $P<0.01$. ↑; Increase, ↓: Decrease. Data are expressed as mean±SE. FBG: Fasting blood glucose, HbA1c: Glycosylated hemoglobin, TC: Total cholesterol, TG: Triglyceride, HDL-C: High-density lipoprotein cholesterol, LDL-C: Low-density lipoprotein cholesterol,
VLDL-C: Very LDL-C, SE: Standard error

Table 4: Effect of honey supplementation on fasting blood glucose, glycosylated hemoglobin levels, and lipid profile in normal subjects

Parameters	Male		Female		Percentage change (male)	Percentage change (female)
	Before	After	Before	After		
FBG	99.07±2.42	92.36±2.61	93.1±2.28	86.8±2.49	6.78↓	6.84↓
HbA1c	4.36±0.20	4.13±0.20*	4.0±0.14	3.9±0.11	5.08↓	2.72↓
TC	203.42±6.16	168.64±4.49**	168.7±11.58	142.5±7.94*	17.10↓	15.53↓
TG	204.86±25.66	163.16±22.83	132.3±9.78	108.2±11.16*	20.35↓	18.23↓
HDL-C	33.05±3.01	35.33±2.06	40.9±4.85	44.8±3.65	6.92↑	9.48↑
VLDL-C	40.97±5.13	32.63±4.57	26.5±1.96	21.6±2.23*	20.35↓	18.23↓
LDL-C	129.40±6.51	100.68±5.26**	101.3±12.69	76.1±8.37*	22.20↓	24.93↓
Risk ratio	6.34±0.36	4.88±0.33**	4.6±0.70	3.3±0.36*	23.06↓	27.39↓

*Significant change $P<0.05$, **Significant change $P<0.01$. ↑; Increase, ↓: Decrease. Data are expressed as mean±SE. FBG: Fasting blood glucose, HbA1c: Glycosylated hemoglobin, TC: Total cholesterol, TG: Triglyceride, HDL-C: High-density lipoprotein cholesterol, LDL-C: Low-density lipoprotein cholesterol, VLDL-C: Very LDL-C, SE: Standard error

males and 18.23% ($P < 0.05$) in females. LDL-C in male group was decreased by 22.20% ($P < 0.01$) and by 24.93% ($P < 0.05$) in female group. VLDL cholesterol in males and females was reduced by 20.35% and 18.23% respectively ($P < 0.05$). Risk ratio was decreased by 23.06% ($P < 0.004$) and 27.39% ($P < 0.05$) in males and females, respectively. An increase of 4.02% and 11.96% in serum HDL-C level was observed in males and females with IGT whereas the increment of 6.92% and 9.48% in HDL-C was noted in males and females of normal healthy group [Table 4].

DISCUSSION

Results of the present study indicate that honey has therapeutic potential if consumed for a prolonged period of time. The study demonstrates the ability of natural honey to modulate FBG and lipid levels in subjects with IGT and healthy subjects which may be attributed to the bioactive constituents present in honey. A considerable lowering of FBG and HbA1c was observed in this study; this highlights that honey administration has a considerable impact on improving IGT and delaying the development of diabetes mellitus.

Honey's fructose level ranges from 21% to 43%, with a fructose/glucose ratio ranging from 0.4 to 1.6 or higher. Despite being the sweetest naturally occurring sweetener, fructose has a GI of 19, compared to 100 for glucose and 60 for sucrose (refined sugar). Honey has been shown to have a hypoglycemic impact in many investigations, although the mechanism behind this action is unknown. Fructose, specific mineral ions (selenium, zinc, copper, and vanadium), phenolic acids, and flavonoids have all been suggested to have a part in the process.

In an animal study done by Chepulis and Starkey, a significantly lower level of HbA1c in rats fed with honey diet compared to sucrose-containing diet was observed.[11] Al-Waili in 2004 reported a reduction in blood glucose levels after honey administration in both diabetic and normal subjects. This may be due to the insulin-sensitizing effect of honey.[12] Yet another study by Yaghoobi *et al*. reported a reduction in FBG levels after consuming a regimen containing honey for 30 days.[13]

Jennings *et al*. studied honey as a substitute for refined sugars and reported that in comparison to sucrose, honey has the potential to decrease glucose, insulin level, and TG concentration over a short period of time.[14] Glucokinase is an enzyme which is involved in the intracellular metabolism of glucose. Studies have shown that dietary fructose is able to activate glucokinase. It catalyzes the conversion of glucose to glucose-6-phosphate, thereby decreasing blood glucose.[15] It may be due to the fact that fructose has a contributory effect in modulating blood glucose.[16]

A study by Grodsky *et al*. on isolated pancreas has shown that the contributory effect of fructose may be due to the fact that it stimulates insulin secretion.[17] Curry *et al*. provided strong evidence on hypoglycemic effect of honey by describing the role of fructose. They reported that in the presence of very low or no glucose concentration, there was no insulin response but with higher concentration of glucose insulin response to fructose was elicited.[18]

Our study has also shown a reduction in BMI after honey supplementation in both normal and subjects having IGT which is in agreement with Chepulis who reported a significant reduction in weight after honey consumption compared to sucrose in short-term feeding.[19] Similarly, Bahrami *et al*. in their 8-week study of honey consumption in diabetic patients also reported beneficial effects of honey on body weight and lipid profile.[20]

Dyslipidemia is a common abnormality seen with diabetic patients, mainly in type 2 diabetes, and increases the risk of ischemic heart disease. Early detection and intervention can reduce the risk of myocardial infarction coronary deaths and overall mortality. Administration of honey in the present study indicated a significant reduction in TG in majority of the subjects with a marked improvement in HDL. In agreement to the reports of the present study, Yaghoobi *et al*. reported a reduction in cardiovascular risk factors in overweight or obese subjects after natural honey administration.[13]

Mushtaq *et al*. have also demonstrated a positive effect of honey on lipid profile of obese compared to normal subjects, mainly by enhancing HDL-C in specific ethnic group.[21] With the increase of even a slight concentration of LDL-C in type 2 diabetes mellitus patients, the LDL particles become qualitatively different and more atherogenic as compared to nondiabetic subjects.[22] In several clinical trials, a strong association between low HDL-C and increased risk of cardiovascular disease (CVD) is observed.[23,24] Small sample size is the main limitation of the present study; a large randomized clinical trial is required to strengthen the findings of the present study.

CONCLUSION

In the present study, honey has demonstrated promising remarkable effect in modifying the traditional CVD risk factors, especially with weight reduction. The present study encourages the use of honey in patients with IGT for longer term.

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Conflicts of interest

There are no conflicts of interest.

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