PJN
ISSN 1680-5194

PAKISTAN JOURNAL OF NUTRITION

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

OPEN ACCESS Pakistan Journal of Nutrition

ISSN 1680-5194
DOI: 10.3923/pjn.2017.61.68

Research Article
Glycemic and Insulinemic Response of Different Types of Jordanian Honey in Healthy and Type 2 Diabetic Volunteers

[1]Alia M. Abu Rajab, [1,2]Hamed R.H. Takruri, [3]Aly A. Mishal and [2]Refat A. Alkurd

[1]Department of Nutrition and Food Technology, Faculty of Agriculture, The University of Jordan, Amman, Jordan
[2]Department of Nutrition, Faculty of Pharmacy and Medical Sciences, University of Petra, Amman, Jordan
[3]Department of Endocrinology, Islamic Hospital, Amman, Jordan

Abstract

Objective: This study aimed to evaluate the Glycemic Index (GI) and Insulin Index (II) values of some types of Jordanian honey. **Materials and Methods:** Six types of honey (citrus, locust pod, Spanish thistle, Christ thorn, mixed flora and sugar honeys) were compared with white bread and sucrose for their glycemic and insulinemic responses, using analysis of variance and pair t-test. The investigation was done on 14 healthy and 9 type 2 diabetic volunteers. **Results:** In healthy volunteers, all types of honey induced lower GI values compared to sucrose and white bread. The GI values of Christ thorn honey (45.4%) and sugar honey (50.8%) were significantly lower ($p<0.05$) than that of sucrose (114.1%). None of the II values induced by all honeys differed significantly from white bread. Only II of sugar honey (75.4%) was significantly lower ($p<0.05$) than that of sucrose. In diabetics, all honeys induced lower GI values than sucrose (132.0%). However, only citrus honey (87.5%) and locust pod honey (93.8%) were significantly lower ($p<0.05$) than that of sucrose. **Conclusion:** Different types of Jordanian honey induced different glycemic and insulinemic responses in healthy and diabetic volunteers. The GI values of these honeys are within the range reported in the international table of GI of honey.

Key words: Glycemic index, insulinemic index, diabetes, honey, white bread

Received: October 21, 2016 Accepted: November 25, 2016 Published: January 15, 2017

Citation: Alia M. Abu Rajab, Hamed R.H. Takruri, Aly A. Mishal and Refat A. Alkurd, 2017. Glycemic and insulinemic response of different types of Jordanian honey in healthy and type 2 diabetic volunteers. Pak. J. Nutr., 16: 61-68.

Corresponding Author: Hamed R.H. Takruri, Department of Nutrition and Food Technology, Faculty of Agriculture, The University of Jordan, Queen Rania Street, 111942 Amman, Jordan

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Diabetes is a widespread, chronic and progressive disease that requires lifelong management[1]. In 2014, the global prevalence of diabetes was estimated to be 9% among adults aged 18+ years[2]. The prevalence of type 2 diabetes has increased dramatically in the Arabic-speaking countries over the last three decades[3]. In Jordan, the prevalence of diabetes was 12%. As in some other Arab populations, diabetes is twice prevalent in Jordan as compared to the USA[4]. The age-standardized prevalence of diabetes and impaired fasting glycemia in Jordan was 17.1 and 7.8%, respectively[5].

The main goal of diabetes treatment is to maintain blood glucose levels within a desirable range to prevent or reduce the risk of complications. The amount of carbohydrate consumed has the greatest influence on blood glucose levels after meals and different carbohydrate-containing foods have different effects on blood glucose levels[1].

Some indices of carbohydrates based on their physiologic effects have been proposed. A well-known index is the Glycemic Index (GI), which is used to classify foods based on their blood glucose raising potential. The GI classification categorizes foods into 3 groups, depending on glucose as a reference as low (<55), medium (55-69) or high GI (>70)[6,7]. Clinical trials in healthy and diabetic subjects show that low-GI diets reduce mean blood glucose concentrations and insulin secretions[6-12].

As a composite biological carbohydrate, honey is regularly used as a natural sweetener and as a traditional medicinal agent[13]. The international table of glycemic index indicates that honey has a GI value ranging[14] from 32-87. This range probably represents the composition differences between honey types[15].

Honey requires lower levels of insulin compared to regular white sugar and does not raise blood sugar levels as rapidly as table sugar, that is it has a lower glycemic index than sugar[16]. Therefore, honey may be a valuable sugar substitute in diabetics[17-19] and long-term consumption of honey might have positive effects on the metabolic derangements of type 1 DM[20].

Additionally, it was shown in a study in both diabetics and controls that the increase in the level of C-peptide after honey consumption was significant when compared with either glucose or sucrose[18]. Munstedt *et al.*[21] and Al-Waili[22] concluded that because of its possible stimulatory effect on diseased beta cells, honey might be considered in future therapeutic trials that target beta cells of pancreas. This conclusion was also reported in other two studies[21,22].

Honey consumption has been shown to give many other health benefits. It reduced elevated blood pressure in hypertensive patients[22] and could provide additional benefits on body weight and blood lipids of diabetic patients[23].

The glycemic index of honey from different countries of the world was measured[8,14,18,19,22,24]. The GI of Jordanian honey has not been determined. Therefore, the objective of this study was to determine the GI and Insulinemic Index (II) of four types of monofloral honey (citrus, locust pod, Spanish thistle and Christ thorn) in addition to mixed flora and sugar honeys and to compare these 6 types of honey with white bread and sucrose.

MATERIALS AND METHODS

Subjects: Twenty three volunteers participated in this study, 14 were healthy non-diabetic subjects and 9 were type 2 diabetic outpatient volunteers treated by diet alone or diet plus oral hypoglycemic agents. The criteria of inclusion of healthy volunteers were to be non-diabetic and to be free of diseases such as heart, liver and kidney were not taking any medications. The clinical characteristics of non-diabetic volunteers are presented in Table 1 and those of the diabetic volunteers are presented in Table 2. The mean Body Mass Index (BMI) of healthy volunteers was 24.3 kg m^{-2} which is within the healthy body weight range, while the mean BMI of diabetic volunteers was 29.4 kg m^{-2} which lies in the overweight body weight range[25].

All volunteers were informed about the study and its objectives. Personal data collection and the experimental procedures were completed after they confirmed their conscious consent to do so.

This study was performed partly in the Islamic Hospital, Amman, Jordan and partly in the Nutrition and Food Technology Department, Faculty of Agriculture in the University of Jordan.

Study design: Each participant had to have from 6-8 experimental sets, once a week, where honey samples, white bread or sucrose solution were randomly served to them in the fasting state (fasting ≥8 h) starting at 8.00 am. The types of Jordanian honey included 5 of floral origin (mixed flora, citrus, locust pod, Spanish thistle and Christ thorn) and one non floral (sugar honey "type 6" obtained from feeding the bees sugar solution, of 2:1 sugar in water). The five diabetic volunteers who were on hypoglycemic agents were instructed not to take their night and/or morning doses before and/or at the day of testing. Five blood samples at 0, 30, 60,

Table 1: Clinical characteristics of the non-diabetic volunteers

Subjects	Sex	Age (years)	Body mass index (kg m^{-2})	Fasting serum glucose (mmol L^{-1})*
1	M	25	26.8	4.53
2	M	27	26.7	4.45
3	M	29	20.4	4.48
4	M	31	24.0	4.67
5	M	38	22.6	5.16
6	M	44	27.8	5.07
7	M	56	26.4	4.57
8	F	22	19.9	4.30
9	F	22	22.4	4.13
10	F	23	18.7	4.38
11	F	23	29.0	4.63
12	F	26	25.3	4.96
13	F	27	22.4	4.14
14	F	37	27.5	4.35
Mean±SEM		30.7±2.6	24.3±0.9	4.56±0.18

M: Male, F: Female, *Mean fasting values in all the sets of each volunteer

Table 2: Clinical characteristics of type 2 diabetic volunteers

Subjects	Sex	Age (years)	Body mass index (kg m^{-2})	Duration of diabetes (years)	Fasting serum glucose (mmol L^{-1})*	Hypoglycemic agent
1	M	30	32.4	1	6.35	None
2	M	43	24.3	0.6	6.83	Glibenclamide
3	M	52	27.7	10	10.10	Glibenclamide
4	M	53	28.6	3	5.49	None
5	M	53	26.4	8	8.00	Metformin
6	M	65	28.3	9	5.44	Glibenclamide
7	F	44	30.4	5	7.79	None
8	F	46	30.6	0.3	5.21	None
9	F	47	35.6	3	10.31	Metformin
Mean±SEM		48±3.2	29.4±1.1	4.4±1.3	7.28±0.70	

M: Male, F: Female, *Mean fasting values in all the sets of each volunteer

90 and 120 min were drawn from each participant in each set from an indwelling cannula in a deep arm vein. The blood samples were drawn in plain tubes and left to form spontaneous clots (10-15 min) then they were centrifuged for 20 min at 3000 rpm. The serum was then pipetted into 1.5 mL tubes and kept at -25°C.

Biochemical analysis: Serum glucose and insulin concentrations were tested in the 2 h testing periods. Serum glucose determination was based on glucose oxidase method[26]. Serum insulin determination was done by a radio-immunoassay method[27].

Calculations and statistical analyses: Data are presented as least square means (LS means)±standard error of the least square means (SE LS means). The serum glucose and insulin responses during a period of 0-120 min were used to plot incremental areas under glucose response curves. These responses were expressed as serum glucose and insulin changes from the fasting state. Incremental and detrimental changes were encountered in calculating areas under serum glucose/insulin response curves[28,29]. Peak increments of glucose and insulin were calculated as the difference between the highest value exhibited by the glycemic and insulinemic responses and fasting concentration. The trapezoidal rule was used for calculating areas under glucose/insulin response curves. The ratio of area under glucose/insulin response curve induced by different honey types and sucrose to those induced by white bread were used to calculate the glycemic and insulinemic index values (GI and II values). General Linear Model Procedure (GLMP) was used for the analysis of variance and paired t-test was used to compare the response means of the treatments.

RESULTS

Glycemic and insulinemic index curves: Figure 1 and 2 show the incremental areas under glucose response curves induced by different test food items in healthy non-diabetic and type 2 diabetic volunteers respectively. In non-diabetic subjects, white bread and sucrose induced significantly higher mean incremental areas under glucose response curves (MIACg) compared to all honey types except for Spanish thistle honey. Also in diabetic volunteers sucrose resulted in the highest MIACg, compared to all other food items.

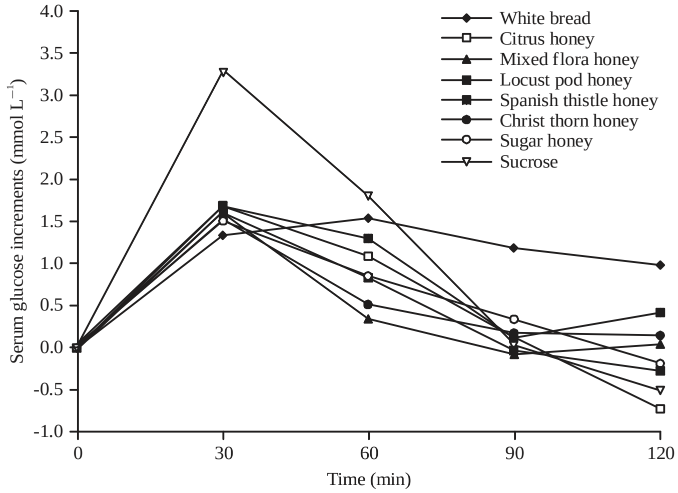

Fig. 1: Incremental areas under glucose response curves induced by test food items in normal subjects

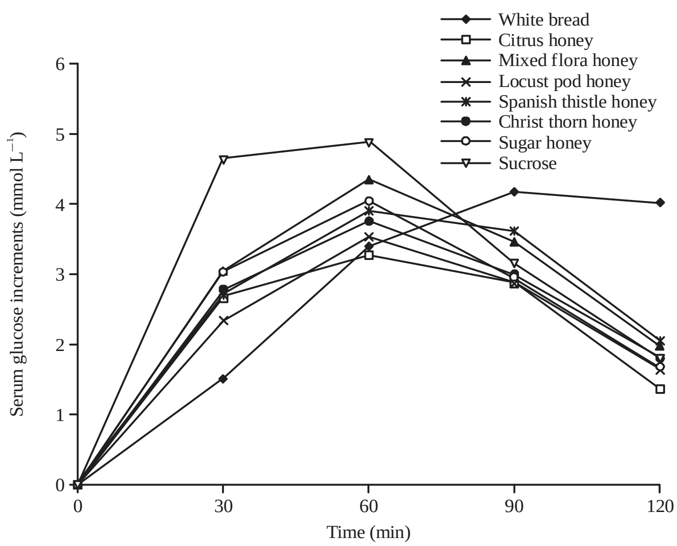

Fig. 2: Incremental areas under glucose response curves induced by test food items in NIDDM subjects

Figure 3 and 4 show the incremental areas under insulin response curves (MIACi) induced by test foods in non-diabetic and diabetic volunteers respectively. In non-diabetic volunteers, MIACi of sucrose and white bread were significantly higher than all honey types. In diabetic volunteers, however, the MIACi of food items were similar except for citrus honey, locust pod honey and Christ thorn honey being insignificantly lower.

Glycemic and insulinemic indices

Non-diabetic subjects: The GI and II values of non-diabetic subjects are presented in Table 3. It is clear from the table that the GI values of all honey types were lower than those of sucrose and white bread. However, no significant differences were obtained between the GI of all honey types and white bread. The GI of the 5 Jordanian floral honey types ranged from 45.4 (Christ thorn) to 85.5 (Spanish thistle). Only GI of Christ thorn honey and that of sugar honey were significantly lower than that of sucrose ($p<0.03$ and $p<0.05$, respectively). The GI of mixed flora honey was on the margin of significance from that of sucrose ($p = 0.053$). Sucrose induced the highest II value. Only II of sugar honey was significantly ($p<0.02$) lower than that of sucrose. None of the II values of different honey types differed significantly from that of white bread.

Type 2 diabetic volunteers: The calculated GI and II values of diabetic volunteers are also presented in Table 3. As in

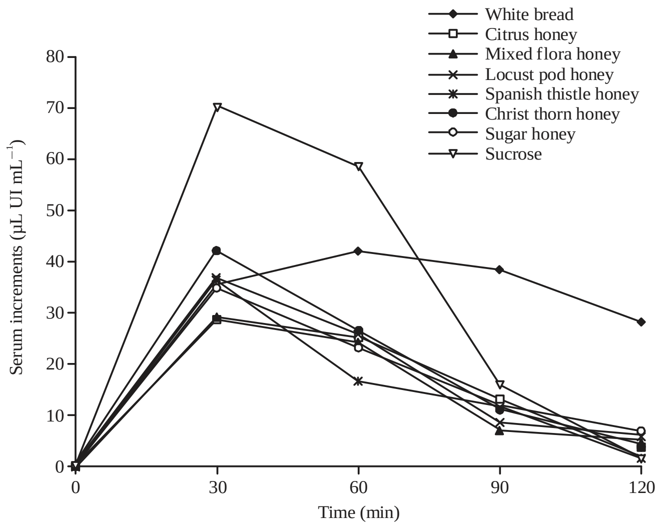

Fig. 3: Incremental areas under insulin response curves induced by test food items in normal subjects

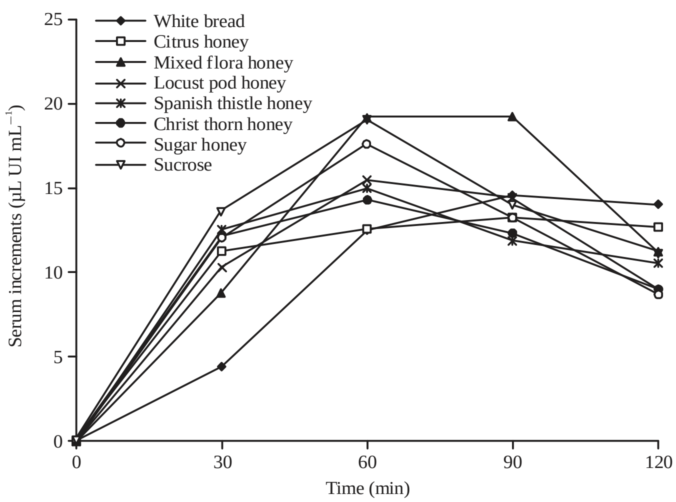

Fig. 4: Incremental areas under insulin response curves induced by test food items in NIDDM patients

Table 3: Glycemic and insulinemic indices induced by test food items in non-diabetic and type 2 diabetic subjects (LS Mean±SE LS Mean)*

		Healthy subjects			Type 2 diabetic subjects	
Food items	N	Glycemic Index (GI) (%)	Insulinemic Index (II) (%)	N	Glycemic Index (GI) (%)	Insulinemic Index (II) (%)
White bread	14	100.0±19.5[ab]	100.0±19.3[ab]	9	100.0±12.6[ab]	100.0±17.9[b]
Citrus honey	14	64.8±19.5[a]	106.0±19.3[ab]	9	87.5±12.6[b]	136.6±17.9[ab]
Mixed flora honey	14	52.0±19.5[a]	104.4±19.3[ab]	9	118.2±12.6[ab]	142.3±17.9[ab]
Locust pod honey	14	68.0±19.5[a]	107.6±19.3[ab]	9	93.8±12.6[b]	128.6±17.9[ab]
Spanish thistle honey	4	85.5±38.1[a]	98.5±37.8[ab]	6	107.3±15.7[ab]	129.1±22.4[ab]
Christ thorn honey	14	45.4±19.5[b]	96.0±19.3[ab]	9	110.1±12.6[ab]	132.1±17.9[ab]
Sugar honey	14	50.8±19.5[b]	75.4±19.3[b]	9	113.7±12.6[ab]	131.9±17.9[ab]
Sucrose	9	114.1±24.9[a]	149.0±24.7[a]	7	132.6±14.5[a]	161.3±20.6[a]

*Least square means in the same column not sharing the same subscript letter are significantly different

non-diabetic subjects, sucrose resulted in the highest GI value compared to all food items. Only GI value of citrus honey (p<0.02) and locust pod honey (p<0.05) were significantly lower than that of sucrose. Also only these two honey types resulted in lower GI values than that of white bread. Furthermore, neither the GI value of sucrose nor that of any honey type differed significantly from GI of white bread. The highest II value induced in diabetic volunteers was that of sucrose. It was significantly higher than that of white bread (p<0.03), whereas the II of all honey types did not differ significantly from each other and from those of white bread and sucrose.

DISCUSSION

Type 2 diabetic volunteers had higher BMI values, this is expected because type 2 diabetes is most prevalent in older, overweight and obese adults[1].

Two of the 5 studied Jordanian honeys could be categorized within low GI (Christ thorn and mixed flora), 2 others were of medium GI (citrus and locust pod) and one was within high GI (Spanish thistle) foods. The high GI of Spanish thistle honey may be explained by the fact that it was tested by only 4 volunteers and to the high variability within these volunteers. Anyway, the GI values of all of the studied Jordanian honeys are within the range of GI values reported in the international table of GI of honey[14].

In healthy volunteers, the glycemic indices of all honeys were significantly lower than that of sucrose solution and insignificantly lower than that of white bread. These results indicate that the glycemic index of honey (which is a mixture of simple sugars) is between that of sucrose (a simple sugar) and that of white bread (complex carbohydrate).

In diabetic volunteers, however, there were no significant differences in GI between all types of honey and white bread, despite that the GIs of citrus and locust pod honeys were lower than that of white bread. On the other hand, the GIs of mixed flora, Spanish thistle and Christ thorn honeys were insignificantly higher than that of white bread. These GI results indicate that the diabetic volunteers responded to all types of honey (monofloral, mixed flora and sugar) in a way similar to that of white bread, despite the insignificant differences. It can be inferred that the diabetic volunteers metabolize the complex carbohydrate in white bread indifferently from that of simple carbohydrates in the studied honeys. In addition, the II of all types of honey in diabetics were insignificantly higher than that of white bread.

Therefore, looking to both GIs and IIs of the studied honeys in diabetic volunteers, it can be concluded that some of the complex carbohydrates allowances in the diabetic diet can be evenly substituted by equivalent amounts of these honeys.

In diabetic volunteers, when comparing the GIs of the honeys and sucrose solution, citrus and locust pod honeys were significantly lower than that of sucrose. On the other hand, when comparing the IIs of the honeys and sucrose solution, the lower values for all types of honey were insignificantly different from that of sucrose.

The amount of carbohydrate ingested is usually the primary determinant of postprandial glycemic response but the type of carbohydrate also affects this response. Fiber, fructose, lactose and fat are dietary constituents that tend to lower glycemic response[30,31]. Two studies stated that the hypoglycemic effect of honey is dose-dependent[24,32]. It may be concluded from the results of this study that the glycemic effect of these honeys may be lower if the amount of ingested honey in one meal provides <50 g of carbohydrate (as performed in the GI and II standard tests). The findings of our study go in line with other researchers who tested the glycemic response of the carbohydrates: glucose, sucrose and honey equivalent to 20 g but not 50 g in normal and type 1 and type 2 diabetic individuals[20], these researchers suggested that honey may be a valuable sugar substitute in diabetics. In another study using type 2 diabetics, the GI of consuming 30 g of honey (which contains 21 g available carbohydrate) was 32.4% compared to that of consuming 25 g of glucose[33]. This conclusion is in agreement with that of Deibert *et al.*[13] who stated that the diet therapy of diabetes does not recommend consumption of this large amount of simple sugar (<50 g from honey or other food sources) separately in one meal without taking them with any other foods[1].

SIGNIFICANCE STATEMENTS

- This study showed that different types of Jordanian honey induced different glycemic and insulinemic responses both in healthy and diabetic subjects
- The glycemic index values of all of the studied honeys fell within the range of glycemic indices reported internationally
- Although composed mainly of simple sugars, honey does not differ significantly from white bread in its glycemic response
- Some types of Jordanian honey had significantly lower glycemic index values than those of sucrose

ACKNOWLEDGMENT

The researchers would like to thank the Deanship of Academic Research at the University of Jordan and Islamic Hospital, Amman, Jordan for financial support through enabling the researchers to conduct this research in their premises.

REFERENCES

1. Rolfes, S.R., K. Pinna and E. Whitney, 2015. Understanding Normal and Clinical Nutrition. 10th Edn., Wadsworth Publishing Company, Stamford, USA.
2. WHO., 2014. Global status report on noncommunicable diseases 2014. World Health Organization (WHO), Geneva, Switzerland, pp: 1-280.
3. Badran, M. and I. Laher, 2012. Type II diabetes mellitus in Arabic-speaking countries. Int. J. Endocrinol., Vol. 2012. 10.1155/2012/902873.
4. Zindah, M., A. Belbeisi, H. Walke and A.H. Mokdad, 2008. Obesity and diabetes in Jordan: Findings from the behavioral risk factor surveillance system, 2004. Prev. Chronic Dis., 5: 1-8.
5. Ajlouni, K., Y.S. Khader, A. Batieha, H. Ajlouni and M. El-Khateeb, 2008. An increase in prevalence of diabetes mellitus in Jordan over 10 years. J. Diabetes Complicat., 22: 317-324.
6. Brand-Miller, J.C., S. Hayne, P. Petocz and S. Colagiuri, 2003. Low-glycemic index diets in the management of diabetes: A meta-analysis of randomized controlled trials. Diabetes Care, 26: 2261-2267.
7. FAO., 1998. Carbohydrates in human nutrition. FAO Food and Nutrition Study No. 66, Report of a Joint FAO/WHO Expert Consultation, Rome, Italy.
8. Atayoglu, A.T., M. Soylu, S. Silici and N. Inanc, 2016. Glycemic index values of monofloral Turkish honeys and the effect of their consumption on glucose metabolism. Turk. J. Med. Sci., 46: 483-488.
9. Wang, Q., W. Xia, Z. Zhao and H. Zhang, 2015. Effects comparison between low glycemic index diets and high glycemic index diets on HbA1c and fructosamine for patients with diabetes: A systematic review and meta-analysis. Primary Care Diabetes, 9: 362-369.
10. Thomas, D.E. and E.J. Elliott, 2010. The use of low-glycaemic index diets in diabetes control. Br. J. Nutr., 104: 797-802.
11. Takruri, H.R. and R.A. Alkurd, 2008. The glycemic index of a new bread brand (Biobread). Jordan Med. J., 42: 117-123.
12. Opperman, A.M., C.S. Venter, W. Oosthuizen, R.L. Thompson and H.H. Vorster, 2004. Meta-analysis of the health effects of using the glycaemic index in meal-planning. Br. J. Nutr., 92: 367-381.
13. Deibert, P., D. Konig, B. Kloock, M. Groenefeld and A. Berg, 2010. Glycaemic and insulinaemic properties of some German honey varieties. Eur. J. Clin. Nutr., 64: 762-764.
14. Atkinson, F.S., K. Foster-Powell and J.C. Brand-Miller, 2008. International tables of glycemic index and glycemic load values: 2008. Diabetes Care, 31: 2281-2283.
15. Wolever, T.M.S., J.C. Brand-Miller, J. Abernethy, A. Astrup and F. Atkinson *et al*., 2008. Measuring the glycemic index of foods: Interlaboratory study. Am. J. Clin. Nutr., 87: 247S-257S.
16. Fessenden, R., 2014. The New Honey Revolution. Salem Publishing Solutions, USA., ISBN: 9781498400671, Pages: 234.
17. Abdulrhman, M., M. El Hefnawy, R. Ali, I.A. Hamid, A.A. El-Goud and D. Refai, 2013. Effects of honey, sucrose and glucose on blood glucose and C-peptide in patients with type 1 diabetes mellitus. Complement. Therapies Clin. Pract., 19: 15-19.
18. Abdulrhman, M., M. El-Hefnawy, R. Hussein and A.A. El-Goud, 2011. The glycemic and peak incremental indices of honey, sucrose and glucose in patients with type 1 diabetes mellitus: Effects on C-peptide level-a pilot study. Acta Diabetologica, 48: 89-94.
19. Samanta, A., A.C. Burden and A.R. Jones, 1985. Plasma glucose responses to glucose, sucrose and honey in patients with diabetes mellitus: An analysis of glycaemic and peak incremental indices. Diabetic Med., 2: 371-373.
20. Abdulrhman, M.M., M.H. El-Hefnawy, R.H. Aly, R.H. Shatla, R.M. Mamdouh, D.M. Mahmoud and W.S. Mohamed, 2013. Metabolic effects of honey in type 1 diabetes mellitus: A randomized crossover pilot study. J. Med. Food, 16: 66-72.
21. Munstedt, K., B. Sheybani, A. Hauenschild, D. Bruggmann, R.G. Bretzel and D. Winter, 2008. Effects of basswood honey, honey-comparable glucose-fructose solution and oral glucose tolerance test solution on serum insulin, glucose and C-peptide concentrations in healthy subjects. J. Med. Food, 11: 424-428.
22. Al-Waili, N., 2003. Intrapulmonary administration of natural honey solution, hyperosmolar dextrose or hypoosmolar distill water to normal individuals and to patients with type-2 diabetes mellitus or hypertension: their effects on blood glucose level, plasma insulin and C-peptide, blood pressure and peaked expiratory flow rate. Eur. J. Med. Res., 8: 295-303.
23. Bahrami, M., A. Ataie-Jafari, S. Hosseini, M.H. Foruzanfar, M. Rahmani and M. Pajouhi, 2009. Effects of natural honey consumption in diabetic patients: An 8-week randomized clinical trial. Int. J. Food Sci. Nutr., 60: 618-626.
24. Erejuwa, O.O., 2014. Effect of honey in diabetes mellitus: Matters arising. J. Diabetes Metab. Disorders, Vol. 13. 10.1186/2251-6581-13-23
25. WHO., 2000. Obesity: Preventing and Managing the Global Epidemic (Technical Report Series No. 894). World Health Organization, Geneva, Switzerland, ISBN-13: 9789241208949, Pages: 253.
26. Trinder, P., 1969. Determination of glucose in blood using glucose oxidase with an alternative oxygen acceptor. Ann. Clin. Biochem., 6: 24-27.
27. Reeves, W.G., 1983. Insulin antibody determination: Theoretical and practical considerations. Diabetologia, 24: 399-403.
28. Le Floch, J.P., P. Escuyer, E. Baudin, D. Baudon and L. Perlemuter, 1990. Blood glucose area under the curve: Methodological aspects. Diabetes Care, 13: 172-175.
29. Gannon, M.C. and F.Q. Nuttall, 1987. Factors affecting interpretation of postprandial glucose and insulin areas. Diabetes Care, 10: 759-763.

30. American Diabetes Association, 2008. Nutrition recommendations and interventions for diabetes: A position statement of the American Diabetes Association. Diabetes Care, 31: S61-S78.
31. Ionescu-Tirgoviste, C., E. Popa, E. Sintu, N. Mihalache, D. Cheta and I. Mindu, 1983. Blood glucose and plasma insulin responses to various carbohydrates in type 2 (non-insulin-dependent) diabetes. Diabetologia, 24: 80-84.
32. Omotayo, E.O., S. Gurtu, S.A. Sulaiman, M.S. Ab Wahab, K.N.S. Sirajudeen and M.S.M. Salleh, 2015. Hypoglycemic and antioxidant effects of honey supplementation in streptozotocin-induced diabetic rats. Int. J. Vitamin Nutr. Res., 80: 74-82.
33. Monro, J.A. and M. Shaw, 2008. Glycemic impact, glycemic glucose equivalents, glycemic index and glycemic load: Definitions, distinctions and implications. Am. J. Clin. Nutr., 87: 237S-243S.