METABOLIC EFFECTS OF HONEY (ALONE OR COMBINED WITH OTHER FOODS) IN TYPE II DIABETICS

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The glycemic response to different carbohydrate foods may vary despite an apparent lack of difference in macronutrient composition [9, 12]. It was postulated that possible differences in the digestion rates of the foods were responsible for the various glycemic responses both in normal and diabetic individuals [4, 8]. On the other hand, some acute experiments, summarized in a recent review [10], suggest that in terms of glycemic response glucose is no worse than some complex carbohydrates, that foods containing sucrose do not necessarily have a high glycemic index, and that fructose produces the lowest glycemic response of all the simple sugars. It was thought, therefore, interesting to investigate the hyperglycemic response to honey in diabetics compared to a regular source of carbohydrate, such as bread. Furthermore, it was also studied whether the postprandial hyperglycemia due to honey ingestion could be attenuated by the addition of some fatty foods.

MATERIALS AND METHODS

Two different study-protocols were used.

A) 12 type II diabetics (tab. 1) consumed two different test meals, on separate days, after an overnight fast, at 08^{00}. Meal H consisted of 33 g of honey and meal B of 50 g of white bread. The meals were practically isoglucidic (approximately 25 g carbohydrates in each meal) and were given in a random order. Ingestion of 180 ml tap water followed each meal.

B) 19 type II diabetics received on different days, after an overnight fast, 3 different meals.

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The composition of each meal, as well as the abbreviations used, are indicated in tab. 2. Details related to the subjects examined are shown in tab. 1.

Meals HA and HB were approximately isoglucidic and contained similar amounts of fat. However, meal HA was much richer in fiber and contained less protein than meal HB.

The subjects examined did not receive any medication affecting glucose tolerance except their regular antidiabetic drugs. All patients studied (protocols A and B) were followed in our Outpatient Diabetic Clinic and had volunteered to participate in the study after receiving detailed information and in accordance with the Helsinki Declaration of 1975. The tests were performed with the patients in a sitting position. Venous blood samples were repeatedly obtained through a heparinized butterfly needle before meals (time 0) as well as at 30, 60, 90, 120, 150 and 180 min after each meal for blood sugar (Technicon Autoanalyzer), serum triglycerides[6] and insulin[7] determination. The last two substances were not measured at 90 and 180 min. Statistical comparisons were done according to Student's *t*-test for paired data.

RESULTS

Table 3 and fig. 1 show the results which correspond to protocol A. Honey resulted in moderately higher mean blood sugar levels at 30 min, as compared to bread, and in lower concentrations thereafter. However the differences between mean values were not statistically significant. Similary, there were no

	sex	age range (years)	BMI range	antidiabetic treatment	known duration of diabetes
protocol A	6 males 6 females	40-70 median = 55	23.9-45.8 median = 28.9	no drugs (diet only)	1 month-6 years
protocol B	9 males 10 females	33-72 median = 57	22.8-34.3 median = 25.5	no drugs (n = 13) glibenclamide (n = 3) gliclazide (n = 3)	3 months-16 years

Tab. 1 - Data concerning the subjects examined.

	content**	carbohydrate (g)	protein (g)	fat (g)
meal H	30 g honey	22.9	0.1	trace
meal HA	30 g honey	22.9	0.1	trace
	100 g almonds****	4.3	16.9	53.5
meal HB	30 g honey	22.9	0.1	trace
	125 g cheese***	—	36.2	41.2
	10 g butter	trace	0.04	8.2
	10 g bread****	4.9	0.7	0.1

* *Most data were obtained from* PAUL *and* SOUTHGATE[13]; ** *each meal was followed by 180 ml of tap water;* *** *type of Greek cheese;* **** *fiber contents: meal HA = 14.3 g; meal HB = 0.27 g.*

Tab. 2 - Meal composition* (protocol B).

time (min)	0		30		60		90		120		150		180	
	B*	H**	B	H	B	H	B	H	B	H	B	H	B	H
blood sugar values (mg/dl)	127.1 ±22.9	127.0 ±24.1	151.4 ±32.1	181.2 ±41.6	193.9 ±33.2	188.9 ±42.9	187.5 ±27.6	170.4 ±36.5	153.2 ±36.9	167.1 ±43.5	152.5 ±30.8	142.3 ±36.6	144.0 ±27.0	134.0 ±30.3
absolute blood sugar changes (mg/dl)			24.2 ±18.1	54.1 ±26.8	66.7 ±16.5	61.8 ±24.1	60.3 ±13.5	43.3 ±19.6	40.8 ±18.7	26.6 ±19.2	25.4 ±17.8	15.2 ±17.8	16.9 ±16.2	7.0 ±15.8
serum triglyceride levels (mg/dl)	149.7 ±33.5	145.0 ±36.1	151.7 ±27.9	143.0 ±40.0	167.0 ±34.6	173.5 ±49.7			166.2 ±36.7	160.7 ±39.8			173.7 ±42.4	175.8 ±37.6
serum insulin levels (μU/ml)	24.8 ±20.4	27.0 ±21.4	47.6 ±23.9	36.8 ±22.1	33.3 ±22.2	31.3 ±23.2			36.1 ±22.8	32.5 ±23.5			31.5 ±16.8	26.5 ±20.1

* *B = meal containing bread;* ** *H = meal containing honey.*

Tab. 3 - Mean (± SD) blood sugar, absolute blood sugar changes (compared to basal values), serum triglyceride and insulin levels in type II diabetics who received isoglucidic amounts of bread and honey (protocol A).

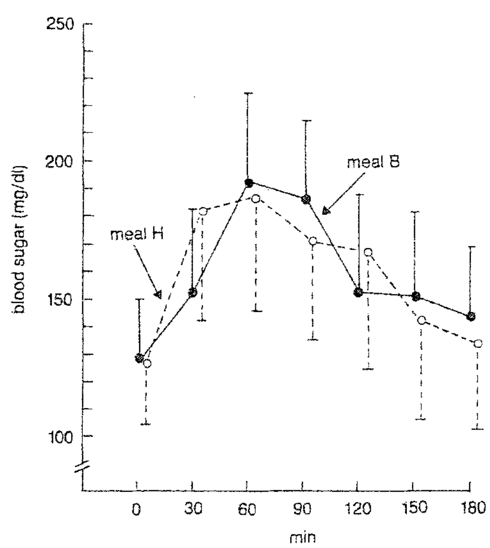

Fig. 1 - Graphic representation of mean (± SD) blood sugar values before and after ingestion of meals B (bread) and H (honey).

time (min)	0	30	60	90	120	150	180
absolute levels							
meal H*	133.1±27.9	183.4±35.9	179.0±33.8	162.5±39.3	145.8±40.8	131.8±39.6	124.0±39.1
meal HA	138.5±28.1	162.5±35.2	181.8±38.9	175.6±41.5	155.4±44.7	140.7±41.8	132.9±41.0
meal HB	138.4±29.8	163.7±38.0	193.5±52.3	182.6±62.5	159.4±54.8	145.1±50.3	136.9±53.9
changes							
meal H		50.2±26.8	50.5±18.6	29.4±21.9	12.6±21.2	-1.2±19.2	-9.0±19.5
meal HA		23.9±17.0	43.2±18.5	37.0±23.0	16.7±22.7	2.1±19.5	6.2±23.7
meal HB		25.2±15.7	55.1±33.2	44.2±41.5	15.1±38.2	6.7±31.5	-3.5±34.0

* *Meal H: honey alone; meal HA: honey and almonds; mean HB: honey, butter, etc. (see text).*

Tab. 4 - Mean (± SD) blood sugar levels (mg/dl) and changes in comparison to basal (0 min) values.

time (min)	0	30	60	120	180
absolute values					
meal H	137.7±58.3	144.5±58.8	147.2±61.1	150.4±62.4	166.2±63.1
meal HA	138.5±55.3	170.5±74.3	175.2±51.6	195.2±63.8	173.2±70.7
meal HB	143.8±55.7	152.1±55.5	180.1±62.5	197.0±67.4	202.5±80.4
percent changes					
meal H		6.6±17.4	8.2±20.2	9.7±16.0	24.3±31.7
meal HA		26.0±41.7	31.5±23.0	39.5±42.3	29.1±40.1
meal HB		7.7±17.1	27.9±23.1	43.8±44.8	44.3±33.4

Tab. 5 - Mean (± SD) serum triglyceride concentrations (mg/dl) and percent changes in comparison to basal (0 min) values.

significant differences between mean areas under the blood sugar curves (bread = 29,607 ± 4,918 mg· min; honey = 29,214 ± 6,054). Absolute blood sugar changes against basal values were found after meal H, compared to B: significantly higher at 30 min ($p<0.01$) and lower at 90 min ($p<0.05$). No significant differences between the two meals were observed as far as mean triglyceride and insulin levels were concerned (tab. 3).

Results obtained after ingestion of mixed meals (protocol B) are indicated in tabs 4, 5 and 6. Tab. 4 shows mean (± SD) absolute blood sugar values, as well as postprandial blood sugar changes in relation to basal levels. Meal H (honey alone) resulted in earlier postprandial hyperglycemia than the other two mixed meals, although there was no significant difference between the meals with regard to mean absolute blood sugar values. The earlier hyper-

time (min)	0	30	60	120	180
meal H	18.4± 6.5	31.2±12.4	28.3±11.7	25.7± 9.5	20.5± 7.8
meal HA	24.3±13.8	45.8±28.8	52.9±33.5	45.4±29.5	33.5±16.3
meal HB	14.7± 2.9	46.6±44.6	78.2±53.7	96.8±57.7	54.8±45.5

Tab. 6 - Mean (± SD) serum insulin (μU/ml).

glycemia following ingestion of meal H was also apparent when mean blood sugar changes were compared to the fasting values (significant differences ($p<0.001$) between meal H and meals HA and HB at 30 min). No significant differences were observed between the areas under blood sugar curves (meal H: 28,348 ± 6,388, meal HA: 29,212 ± 7,508 and HB: 29,467 ± 8,505 mg· min).

Serum triglyceride concentrations (tab. 5) were - as expected - higher after ingestion of meals HA and HB compared to H. However, due to large standard deviations, differences between different levels were not statistically significant. When the same data were expressed as percentage changes against basal values, the mean triglyceride level observed at 60 min after meal HA was significantly higher than the corresponding value for meal H ($p<0.05$).

Mean serum insulin levels (tab. 6) were generally higher after meal HB and lower after meal H while intermediate values were observed in the case of meal HA. Differences between mean values were significant at 60 and 120 min when meal HB was compared to meal H ($p<0.05$ and <0.01, respectively).

DISCUSSION

There is undoubtedly a need for sweeteners in the diabetic diet to improve overall dietary compliance. Sugar substitutes can be obtained conveniently and cheaply from commonly available food items[16]. The present study indicates that honey could be suitable for this purpose. It was seen that honey does not produce greater hyperglycemia in comparison to isoglucidic amounts of bread. This is not surprising when we take into account that honey contains not only glucose but also fructose. It is well known that fructose is absorbed more slowly from the gastrointestinal tract than glucose and is primarily and rapidly taken up by the liver. Consequently, blood sugar levels rise only minimally after fructose ingestion[5,10]. Two studies have shown that honey consistently produces a lower glycemic effect when compared to glucose and sucrose in normal volunteers and type I diabetics[14] and that honey or sucrose at breakfast do not have additional acute hyperglycemic effects over an isoglucidic amount of bread in type II diabetics[2]. It should be remembered that several studies have already shown that certain sugars, even when eaten alone, are less hyperglycemic than some starch-containing foods in diabetic patients[1,15].

Since people do not primarily eat pure carbohydrate, it was further investigated what occurs when honey is ingested in combination with other usual foods, as a mixed meal. There are some data indicating that when individual carbohydrate foods are taken as part of a mixed meal, differences in glycemic responses between the foods are abolished[3,11]. Our study showed that although honey (alone) resulted in an early blood sugar increase, higher than that observed after ingestion of mixed meals, the total postprandial hyperglycemia was practically the same for the three meals studied. In other words, the increase of ingested calories, either in the form of almonds or butter and cheese, did not give rise to a further hyperglycemic effect. Apparently, the addition of fat resulted in the relative flattening of the blood sugar curve.

Meal HA contained the same amount of carbohydrates and approximately the same amount of fat as meal HB, but was much richer in fiber. In spite of this, there was no significant difference in mean blood sugar values between these two meals. This lack of difference could possibly be due to the fact that meal HA contained, as already mentioned, less protein than meal HB. Therefore, the expected higher blood glucose level after meal HB, which was low in fiber, could have been counteracted by the increased insulin secretion induced by this meal (richer in protein) as suggested by the higher insulin levels found after meal HB (tab. 6). Both meals HA and HB were followed, as expected, by higher triglyceride and insulin concentrations compared to meal H.

SUMMARY

The metabolic effects of honey - alone or combined with other foods - were investigated in type II diabetics using 2 protocols: A) 33 g honey and 50 g bread (same amounts of carbohydrate) were given on alternate days to 12 patients. Blood levels of glucose, insulin and triglycerides were determined in venous samples before and every 30 min after meal ingestion (for a total of 3h). Areas under glucose curves were equal, although honey - compared to bread - resulted in higher blood sugar concentrations at 30 min ($p<0.01$) and lower at 90 min ($p<0.05$). B) Another 19 type II diabetics consumed on separate days 3 different meals: H (30 g honey), HA (30 g honey, 100 g almonds), HB (30 g honey, 125 g cheese, 10 g bread, 10 g butter). HA and HB contained the same amount of fat, but were different in fiber. No significant differences in the areas under glucose curves were observed. However, meal H produced earlier hyperglycemia than HA and HB (30 min: $p<0.01$). Insulin levels were higher after HB compared to H ($p<0.05$). Meals HA and HB were followed by higher triglyceride levels than H ($p<0.05$). It is concluded that: 1) honey and bread produce similar degrees of hyperglycemia in type II diabetics. 2) Fat-rich foods added to honey do not alter the total hyperglycemic effect but result in higher triglyceride and insulin serum concentrations.

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