DETERMINATION OF THE GLYCAEMIC INDEX OF SELECTED FOODS (WHITE BREAD AND CEREAL BARS) IN HEALTHY PERSONS

Rudolf Chlup^{a*}, Josef Bartek^b, Martina Řezníčková^a, Jana Zapletalová^c, Blanka Doubravová^d,
Ludmila Chlupová^e, Pavel Sečkař^f, Svatava Dvořáčková^b, Vilím Šimánek^b

^a Institute of Physiology and IInd Department of Medicine, Palacký University & Hospital, 77520 Olomouc, Czech Republic; e-mail: rudolf.chlup@fnol.cz

^b Institute of Medical Chemistry and Biochemistry, Faculty of Medicine, Palacký University, Olomouc

^c Department of Biometrics, Faculty of Medicine, Palacký University, Olomouc

^d Institute of Neurology and Geriatrics, Moravský Beroun

^e Department of Special Education, Faculty of Paedagogics, Palacký University, Olomouc

^f Department of Health Insurance, Teaching Hospital, Olomouc

Received: May 25, 2004; Accepted: June 15, 2004

Key words: Diabetes mellitus/Glycaemic index/Cereal bars/White bread/Carbohydrates/Glucometer

The glycaemic index (GI) is a measure of the food power to raise blood glucose (B-glucose) concentration after a meal. For healthy eating, foods with low GI are recommended. However, for many foods in the European Union the GI has not been defined yet. The aims of this prospective open-label study were: (1) to determine the GI of white bread and juicy cereal bars FIT (Úsovsko, Czech Republic) by means of the glucometer Optium (Abbott/Medisense); (2) to compare the GI of tested foods determined in the morning and in the evening hours; (3) to compare the GI of tested foods in men and women and (4) to assess the variability of the GI. Methods: To determine the GI, measured portions of food containing 50 g of carbohydrates were eaten by 11 healthy volunteers. B-glucose curves were constructed from B-glucose values at time 0, 15, 30, 45, 60, 60, 120 min after the meal. The GI was calculated by dividing the incremental area under the curve (IAUC) for the tested food by that for the standard food (IAUCS). In each volunteer each food was tested 5 times so that 5 GI's was obtained and the average was calculated. The GI for each tested food was calculated as the mean from the respective average GI's of the 11 volunteers. MS Excel and the statistical program SPSS v. 10.1 were used to analyze the data. Results: (1) The mean values of the GI for white bread was 70.3 % and for juicy cereal bars was 101.0 %, as determined in a total of 139 tests in the whole group of 11 volunteers. There was a difference when comparing white bread vs. glucose ($p = 0.012$) and white bread vs. cereal bars ($p = 0.026$) but no difference between glucose and cereal bars. (2) There was no significant difference between the GI determined in the morning and in the evening hours either for the total of 139 tests or for the individual tested foods. (3) No significant difference could be seen between the GI in men and women when comparing glucose, cereal bars and white bread. (4) There was a wide variability of GI in all tested foods: the standard deviation of GI for white bread was 30.7 %, for juicy cereal bars 38.0 %. Conclusions: The GI's for white bread and juicy cereal bars were determined. There was no difference either between the GI values determined in the morning vs. the evening hours or between the values in men vs. women. The results show wide variability. An accurate standard method for the determination of GI needs to be defined, carefully used and re-evaluated to enable a comparison of the results with various methods of other working groups.

INTRODUCTION

The glycaemic index (GI) is an important parameter of food quality which compares the hyperglycaemic effect of a tested meal with pure glucose (or of another defined standard food). The GI is a measure of the food power to raise B-glucose concentration after a meal. The GI is defined as relation of the incremental area under the B-glucose response curve (IAUC) of a tested meal containing 50 g of digestible carbohydrates and the incremental area under the B-glucose response curve of the standard food, i.e. 50 g pure glucose (IAUCS). Carbohydrates that breakdown quickly during digestion have a high GI because

their B-glucose response is fast and high. Carbohydrates that breakdown slowly have a low GI¹¹.

For healthy eating, particularly in persons with diabetes, obesity and insulin resistance, foods with low GI are recommended as they may help keep the euglycaemia and the normal spectrum of lipoproteins^{3, 4, 8, 12, 22}. These effects result in decreased cardiovascular danger and probably also in reduced risk for colon and breast cancer¹.

On the other hand, the GI values have a large inter- and intraindividual variability^{18, 19, 24}. For many foods in the European Union the glycaemic index has not been defined yet. Even the methods for defining the GI are not standardized¹³. Therefore, any effort to enable the

determination and practical use of GI may support establishing optimum dietary recommendations and good eating habits.

AIMS

Aims of this prospective open-label study were:

1. to determine the GI of white bread and cereal bars by means the glucometer system Optium;
2. to compare the GI of tested foods determined in the morning and in the evening hours;
3. to compare the GI of tested foods in men and women;
4. to assess the variability of the GI.

METHODS

Determination of the glycaemic index

a) Getting basic data

To determine the GI, measured portions of tested food containing 50 g of carbohydrates were eaten by each of the 11 healthy volunteers (Table 1) after an overnight fast; the same approach was used after an afternoon fast. Finger-prick blood samples were investigated at 15–30 minute intervals over the next two hours after the meal (at times 0, 15, 30, 45, 60, 90, 120 min; the beginning of the food intake was time 0).

Each volunteer measured his/her B-glucose concentrations by means of a glucometer Optium. At the end of the one-week test period the B-glucose values were transferred from the memory of the glucometer into a PC for further analysis.

b) Construction of B-glucose response curves.

The averages of the respective B-glucose concentrations after the meal were used to draw a B-glucose response curve for the two-hour period. The values at times 75 and 105 min were obtained by extrapolation.

c) Exclusion of disturbed tests.

For the purpose of statistical evaluation, all tests that were not complete and all tests where the first (i.e. fasting) B-glucose concentration was 7.0 mmol/l or higher were excluded.

d) Calculations of individual GI values in every volunteer.

The incremental area under the curve (IAUC) was calculated for each meal in every volunteer separately (as the sum of the surface of triangles and trapezoids between the B-glucose curve and horizontal baseline going parallel to x-axis from the beginning of B-glucose curve at time 0 to the point at time 120 min) to reflect the total rise in B-glucose concentration after eating the tested food.

The IAUCS for the standard reference food (i.e. 50 g of pure glucose) was obtained similarly to the mean from the first three independent IAUCS₁, IAUCS₂, IAUCS₃ in the same volunteer.

In the IAUC/IAUCS calculations, all B-glucose values in the course of the test lower than the first value (at

time 0) were equalized to the respective first value.

In each volunteer, the GI (%) was calculated by dividing the IAUC for the tested food by the IAUCS for the standard food and multiplying by 100. The following formula was used:

$$GI = \frac{IAUC}{\frac{1}{3}(IAUCS_1 + IAUCS_2 + IAUCS_3)} \times 100 [\%]$$

IAUC – Incremental Area Under the blood glucose response Curve for the tested meal

IAUCS – Incremental Area Under the blood glucose response Curve for the standard meal

e) Working out the average of GI's for tested food in each volunteer.

In each volunteer each food item was tested 5 times so that 5 GI's was obtained and (after the exclusion of disturbed tests) the average was calculated.

f) Final calculation of the GI for each tested food.

The GI for each tested food was calculated as the mean from the respective average GI's of the 11 volunteers.

g) The variability of GI for each tested food was assessed according to standard deviation of the mean; histograms of GI values demonstrated the frequency and range of results.

Healthy volunteers

The participants in this study were healthy persons recruited from the nursing staff, laboratory assistants and students. Thorough clinical and laboratory investigations were performed to establish that the volunteers were healthy. (Table 1).

Tested foods

Three different foods (A–C) with a known content of nutrients were tested:

- A. pure glucose, one serving 50g;
- B. white bread (Vodová veka Penam, Olomouc, Czech Republic); composition: carbohydrates 59.0 %, protein 9.0 %, fat 1.2 %, energy 1190 kJ /100g; one serving 85 g (equal 50.0 g of carbohydrates);
- C. juicy cereal bar (šťavnatá tyčinka FIT, Ústevsko, Czech Republic); composition: carbohydrates 68 %, proteins 5.9 %, fat 13 %, energy 1740 kJ/100g; one serving 75 g (equal 50.0 g of carbohydrates).

The food was professionally prepared in the expected quality and quantity; the portions were packed and marked with a set sign. Each serving contained 50 g of digestible carbohydrates. Glucose was dissolved in 300 ml of tea, coffee or water before drinking.

Study design

1. Each volunteer received a glucometer Optium and 100 strips (Lot No 51322); everyone was trained in selfmonitoring and instructed how to keep to the principles of the study protocol:
 - to consume the tested and the standard food

Table 1. Characteristics of healthy volunteers in the study.

Parameter	Mean $\pm$ SE	Reference range
n	11	
men/women	5/6	
Age [years]	24.0 $\pm$ 2.02	
BMI [kg/m ²]	22.8 $\pm$ 0.96	< 25
Puls rate [min ⁻¹]	76.4 $\pm$ 3.16	60 – 90
Blood pressure systolic [torr]	121.4 $\pm$ 3.28	< 130
Blood pressure diastolic [torr]	74.1 $\pm$ 2.21	< 85
HbA1c [%]	5.5 $\pm$ 0.07	4.4. – 6.0
T3 [nmol/l]	1.6 $\pm$ 0.07	1.2 – 3.1
T4 [nmol/l]	90.9 $\pm$ 6.73	58 – 142
TSH [mU/l]	1.9 $\pm$ 0.39	0.35 – 4.4
STH [ng/ml]	1.0 $\pm$ 0.38	0 – 4.1
Cortisol [nmol/l]	454.3 $\pm$ 72.81	330 – 710
C-peptid [nmol/l]	0.7 $\pm$ 0.05	0.59 – 1.30
Insulin [mIU/l]	9.4 $\pm$ 1.05	7.1 – 15.6
Cholesterol [mmol/l]	4.6 $\pm$ 0.30	3.5 – 5.2
LDL-cholesterol [mmol/l]	2.9 $\pm$ 0.20	1.20 – 2.60
HDL-cholesterol [mmol/l]	1.5 $\pm$ 0.10	1.20 – 2.30
Triacylglycerols [mmol/l]	1.1 $\pm$ 0.15	0.8 – 1.7
C-reactive protein [mg/l]	11.1 $\pm$ 1.64	< 5.0
Total protein [g/l]	72.6 $\pm$ 1.13	60 – 80
Albumin [g/l]	45.6 $\pm$ 0.60	35 – 50
Glucose [mmol/l]	4.5 $\pm$ 0.12	3.5 – 6.0
Na [mmol/l]	142.2 $\pm$ 0.49	135 – 146
K [mmol/l]	4.3 $\pm$ 0.08	3.7 – 5.2
Cl [mmol/l]	105.3 $\pm$ 0.53	96 – 110
Ca [mmol/l]	2.5 $\pm$ 0.03	2.2 – 2.65
P [mmol/l]	1.4 $\pm$ 0.12	0.7 – 1.6
Mg [mmol/l]	1.0 $\pm$ 0.05	0.65 – 1.15
Urea [mmol/l]	4.3 $\pm$ 0.24	2.6 – 8.5
Creatinin [μ mol/l]	85.1 $\pm$ 3.08	55 – 95
Uric acid [μ mol/l]	322.0 $\pm$ 21.8	180 – 370
Bilirubin [μ mol/l]	11.2 $\pm$ 0.92	< 20.0
ALT [μ kat/l]	0.55 $\pm$ 0.15	< 0.56
AST [μ kat/l]	0.47 $\pm$ 0.06	< 0.52
GMT [μ kat/l]	0.35 $\pm$ 0.05	< 0.63
ALP [μ kat/l]	1.8 $\pm$ 0.68	< 2.10

Table 2. The time schedule for individual tests with food A (glucose), B (white bread) and C (juicy cereal bars) used by each volunteer.

Day	Mo	Tue	Wed	Thu	Fri	Sat	Sun	Mo
Breakfast	-	B1	A2	C2	B3	A4	C4	B5
Dinner	A1	C1	B2	A3	C3	B4	A5	C5

daily for breakfast (6:00–7:00 h) and for dinner (18:00–19:00 h) according to the given schedule (Table 2); no other food was allowed for breakfast and dinner;

- to consume no food from dinner until breakfast and from lunch to dinner; drinking water, mineral water, tea and coffee without sugar was allowed;
 - to keep to the same extent of physical exercise during the whole one-week test period;
 - to consume no alcohol and not to smoke.
2. Each volunteer received 15 servings of standard and tested foods with an exact marking when to eat which serving.
 3. Each volunteer kept a diary on food intake, exercise and results of B-glucose selfmonitoring.
 4. The PC Link was used to transfer the data from glucometer Optium to a PC. MS Excel and statistical program SPSS v. 10.1 were used to analyze the data.

RESULTS

Blood glucose curves

A total of 164 tests (with each food 55 tests, one test with white bread was omitted) were performed.

The mean 2-hour B-glucose curves for pure glucose, white bread and cereal bars are drawn in Fig. 1.

The mean B-glucose curves in the morning ($n = 77$) and in the evening ($n = 87$) for all kinds of tested foods are shown in Fig. 2 and for the individual tested foods in Fig. 3–5.

The mean B-glucose curves for 5 men ($n = 74$ and 6 women ($n = 90$) comparing all kinds of food together are demonstrated in Fig. 6 and curves comparing individual foods in Fig. 7–9.

Statistical evaluation of GI values for tested foods

Due to incomplete number of B-glucose estimations or due to high B-glucose concentration at start (≥ 7.0 mmol/l), 25 tests (15.1 %) had to be excluded from the statistical analysis.

Table 3. Glycaemic index GI of juicy cereal bars and white bread in 11 volunteers (5 men, 6 women); mean $\pm$ SD [%].

Group	GI for cereal bars	GI for white bread
Whole group	101.0 ^b $\pm$ 30.74	70.3 ^{a, b} $\pm$ 37.98
Men	77.5 ^a $\pm$ 17.89	61.9 ^a $\pm$ 27.18
Women	120.7 ^b $\pm$ 40.13	77.3 ^b $\pm$ 34.20
Breakfast	85.3 $\pm$ 53.83	74.6 $\pm$ 34.69
Dinner	114.7 ^b $\pm$ 42.53	68.9 ^{a, b} $\pm$ 30.56

$p < 0.05$ ^a tested food vs. glucose, ^b cereal bars vs. white bread

Fig. 1. Mean B-glucose curves (glucometer Optium) for glucose, white bread and cereal bars; each meal contained 50g of carbohydrates; in all 11 volunteers a total of 164 tests were performed (in every volunteer 5 tests with glucose, 5 tests with white bread and 5 tests with cereal bars); one test with bread was omitted; $\bar{x} \pm$ SEM

Fig. 2. Mean B-glucose curves (glucometer Optium) after consumption of 50g of carbohydrates for breakfast and for dinner: in every volunteer 7 tests for breakfast (3 tests with glucose, 2 tests with bread, 2 tests with cereal bars) and 8 tests for dinner (2 tests with glucose, 3 tests with bread, 3 tests with cereal bars) were performed; one test with bread was omitted; $\bar{x} \pm$ SEM

Fig. 3. Mean B-glucose curves (glucometer Optium) after consumption of 50 g of glucose for breakfast and for dinner: in every volunteer 3 tests for breakfast and 2 tests for dinner were performed; $\bar{x} \pm \text{SEM}$

Fig. 4. Mean B-glucose curves (glucometer Optium) after consumption of 85 g of white bread for breakfast and for dinner: in every volunteer 2 tests for breakfast and 3 tests for dinner were performed; $\bar{x} \pm \text{SEM}$

Fig. 5. Mean B-glucose curves (glucometer Optium) after consumption of 75 g of cereal bars for breakfast and for dinner: in every volunteer 2 tests for breakfast and 3 tests for dinner were performed; $\bar{x} \pm \text{SEM}$

Fig. 6. Mean B-glucose curves (glucometer Optium) after consumption of 50 g of carbohydrates (glucose, white bread, cereal bar): a total of 74 tests in 5 men and a total of 90 tests in 6 women were performed; one test with bread was omitted; $\bar{x} \pm \text{SEM}$

Fig. 7. Mean B-glucose curves (glucometer Optium) after consumption of 50 g of glucose in 5 men (25 tests) and in 6 women (30 tests) were performed; $\bar{x} \pm \text{SEM}$

Fig. 8. Mean B-glucose curves (glucometer Optium) after consumption of 85 g of white bread in 5 men (24 tests) and in 6 women (30 tests) were performed; one test was omitted; $\bar{x} \pm \text{SEM}$

Fig. 9. Mean B-glucose curves (glucometer Optium) after consumption of 75 g of cereal bars in 5 men (25 tests) and in 6 women (30 tests) were performed; $\bar{x} \pm \text{SEM}$

Fig. 10. Glycaemic index for glucose (n = 43), white bread (n = 47) and cereal bars (n = 49) in the 11 volunteers; median, quartiles and outliers;

Fig. 11. Glycaemic index for glucose, white bread and cereal bars in 5 men: median, quartiles, outlier

Fig. 12. Glycaemic index for glucose, white bread and cereal bars in 6 women: median, quartiles

Fig. 13. Histogram of glycaemic indexes (n = 47) for white bread

The mean values of the GI for glucose, cereal bars and white bread determined in a total of 139 tests in the whole group of 11 volunteers are shown in Table 3. There was a significant difference when comparing white bread vs. glucose ($p = 0.012$) and white bread vs. cereal bars ($p = 0.026$) but no difference between glucose and cereal bars ($p = 0.732$) could be seen (Fig. 10).

There was no significant difference between the GI determined in the morning and in the evening hours neither for the total of 139 tests nor for the individual tested foods.

No significant difference could be seen between the GI in 5 men and the GI in 6 women when comparing glucose, cereal bars and white bread. However, in men, there was a significant difference between the GI for white bread vs. glucose ($p = 0.004$) and cereal bars vs. glucose ($p = 0.044$) – see Fig. 11; in women, the only significant difference was between white bread vs. cereal bars ($p = 0.047$) – see Fig. 12.

Variability of GI

The standard deviations of GI see Table 3. The histograms (Fig. 13–14) demonstrate the frequency of GI values in individual tested foods.

DISCUSSION

The concept of the glycaemic index of foods has been developed in the course of the last thirty years without having reached its final version^{22, 25}.

Recent studies from Harvard School of Public Health indicate that the risks of diseases such as type 2 diabetes and coronary heart disease are strongly related to the GI of the overall diet. In 1999, the World Health Organisation (WHO) and Food and Agriculture Organisation (FAO) recommended that people in industrialised countries base their diets on low-GI foods in order to prevent the most common diseases, such as coronary heart disease, diabetes and obesity^{5, 7, 9, 10, 14, 15, 17, 23}.

Fig. 14. Histogram of glycaemic indexes (n = 49) for cereal bars

Some foods on the world market already show their GI rating on the nutrition information panel. Terms such as complex carbohydrates and sugars, which commonly appear on food labels, are now recognised as having little nutritional or physiological significance. The WHO/FAO recommend that these terms be replaced with the total carbohydrate content of the food and its GI value.

In the Czech Republic, however, we were not able to find any food product containing the nutritional label with GI value.

International Tables of Glycaemic Index were published by the American Journal of Clinical Nutrition in 1995 and 2002⁶. Tables of the GI values contain about 600 different foods. According to GI, foods may be divided into three groups: foods with low GI (GI = 55 % or less), foods with medium GI (GI = 56–69 %) and foods with high GI (GI = 70 % or more).

The GI values of foods must be measured using valid scientific methods^{16, 20, 21}. The accuracy of the measurements of the GI is influenced particularly by the following factors²:

1. method for calculating IAUC;
2. method for measuring the B-glucose;
3. defining the amount of the tested food which contains 50 g of hyperglycaemic (i.e. absorbable, digestive) carbohydrates;
4. the usage of the standard food (defining the amount and the kind of the white bread that contains 50 g of digestive carbohydrates);
5. tested individuals;
6. the glycaemia variability from day to day;
7. time of the day when the test is carried out.

In this study, the glucometers Optium were used by 11 trained volunteers. Optium system enabled a reliable registration of all B-glucose values including exact times of measurement even though it was not possible to keep an eye on the performance of the test. Over 50 tests carried out with each tested food in order to investigate the GI exceeds the usual amount of tests used by other working

groups. The tests were performed not only in the morning but also in the evening hours which does not correspond to the recommended method of GI investigation. Nevertheless, no significant difference of GI was found between breakfast and dinner times.

Defining the amount of tested food could be a potential source of mistakes. We have used the declared content of carbohydrates in each food to calculate the amount of food for the tests but we were not able to check the accuracy and precision of these declared data (except the pure glucose which we weighed alone).

A wide range of GI values for individual foods demonstrated by the respective standard deviations and histograms corresponds to the experience of others^{2, 19, 24}. Attention must be paid to the standardization of methods of investigation and their comparison with the methods of other laboratories.

Currently, only a few nutrition research groups around the world provide a legitimate testing service. E.g. in Australia, Sydney University GI Research Service (SUGiRS) was established in 1995 to provide a reliable commercial GI testing laboratory for the local and international food industry. Foods are tested in healthy volunteers according to standardised methods that have been validated against laboratories overseas. Insulin, satiety, hunger and other parameters can be assessed simultaneously. Foods that meet nutrition guidelines and have been GI tested can carry the GI symbol.

The research group at the Human Nutrition Unit at Sydney University has determined the GI values of more than 400 foods using the following method:

1. The GI value of a food is determined by feeding 10 or more healthy people a portion of the food containing 50 grams of digestible (available) carbohydrate and then measuring the effect on their B-glucose concentrations over the next two hours. For each person, the incremental area under their two-hour B-glucose response (IAUC) for this food is then calculated.
2. On another occasion, the same 10 people consume an equal-carbohydrate portion of glucose (the reference food) and their two-hour B-glucose response is also measured.
3. A GI value for the test food is then calculated for each person by dividing their B-glucose IAUC for the test food by their B-glucose IAUC for the reference food.
4. The final GI value for the test food is the average GI value for the 10 people.

It would be certainly worthwhile to compare the GI values obtained by this simple Australian method with the method used in this study.

CONCLUSIONS

1. The GI's for white bread and juicy cereal bars were determined.
2. There was no difference between the GI values determined in the morning vs. the evening hours.

3. There was no difference between the GI values determined in men vs. women.
4. The GI values show wide variability.

An accurate standard method for the determination of GI needs to be defined, carefully used and re-evaluated to enable comparison of results with various methods of other working groups. Increased interest in GI determination may be expected. Hence, adequate facilities and equipment should be made available to fulfil the demands.

ACKNOWLEDGEMENT

The study was supported by the Research Projects, Ministry of Education, Youth and Physical Culture, Czech Republic, No MSMT 151100003 and MSMT 151100005 and by grant of the Ministry of Health, Czech Republic, IGA Nr 7825.

REFERENCES

1. Augustin LS, Gallus S, Bosetti C, Levi F, Negri E, Franceschi S, Dak Maso L, Jenkins DJ, Kendal CW, La Vecchia C. (2003) Glycemic index and glycemic load in endometrial cancer. *Int J Can* 105, 404–407.
2. Berger M. (1995) Diabetes mellitus I. Urban & Schwarzenberg, München, Wien, Baltimore, 135–157.
3. Bornet FRJ, Costagliola D, Rizkalla SW, Blayo A, Fontvieille AM, Haardt MJ, Letanoux M, Tchobroutsky G, Slama G. (1987) Insulinemic and glycemic indexes of six starch-rich foods taken alone and in a mixed meal by type-2 diabetics. *Am J Clin Nutr* 45, 588–595.
4. Brand-Miller JC, Holt SH, Pawlak DB, McMillan J. (2002) Glycemic index and obesity. *Am J Clin Nutr* 76, 2815–2855.
5. Bruns W, Wagner D, Taubert FP. (1989) Untersuchung zum Verhalten von Glykämie, Insulinämie und Lipiden bei stoffwechselgesunden Nichtdiabetikern und Typ-2 (non-insulindependent) Diabetikern unter 3 bzw. 6 Mahlzeiten. *Abstract Akt Endokr Stoffw* 10, 85.
6. Foster-Powell K, Holt SH, Brand-Miller JC. (2002) International table of glycaemic index and glycaemic load values. *American Journal of Clinical Nutrition* 76, 5–56.
7. Gannon MC, Nuttall FQ, Krezowski PA, Billington CJ, S. Parker. (1986) The serum insulin and plasma glucose responses to milk and fruit products in type-2 (non-insulin-dependent) diabetic patients. *Diabetologia* 29, 784–791.
8. Heilbrann LK, Noakes M, Clifton PM. (2002) The effect of high- and low-glycemic index energy restricted diets on plasma lipid and glucose profiles in type 2 diabetic subjects with varying glycaemic control. *J Am Coll Nutr* 21, 120–127.
9. Jenkins AL, Jenkins DJ, Zdravkovitz U, Wursch P, Vuksan V. (2002) Depression of glycemic index by high levels of beta-glucan fiber in two functional foods tested in type 2 diabetes. *Eur J Clin Nutr* 56, 622–628.
10. Jenkins DJ, Kendall CW, Augustin LS, Franceschi S, Hamidi M, Marchie A, Jenkins AL, Axelsen M. (2002) Glycemic index: overview of implications in health and disease. *Am J Clin Nutr* 76, 2665–2673.
11. Jenkins DJ, Kendall CW, Augustin LS, Vuksan V. (2002) High-complex carbohydrate or lente carbohydrate foods? *Am J Med* 113, Suppl 98, 30S–37S.
12. Kabir M, Oppert JM, Vidal H, Bruzzo F, Fiquet C, Wursch P, Slama G, Rizkalla SW. (2002) Four-week low-glycemic index break-

- fast with a modest amount of soluble fibers in type 2 diabetic men. *Metabolism: Clinical & Experimental* 51, 819–826.
13. Klein O, Nosek L, Plate J, Landvogt A, Heise T. (2003) Determination of the glycaemic index in diet products: how to overcome the limitations of the classical approach. 18th Congress of the International Diabetes Federation, Paris, France, 24–29 August.
 14. Liu S, Willett WC. (2002) Dietary glycaemic load and atherothrombotic risk. *Curr Atheroscler Rep* 4, 454–61.
 15. Ludwig DS. (2002) The glycaemic index: physiological mechanisms relating to obesity, diabetes, and cardiovascular disease. *JAMA* 287, 2414–2423.
 16. Otto H, Niklas L. (1989) Deklaration des G-G-Anteils in Vollkornbrot. Abstract. *Akt Endokr Stoffw* 10, 118.
 17. Raben A. (2002) Should obese patients be counselled to follow a low-glycaemic index diet? No. *Obesity Reviews* 3, 245–256.
 18. Rasmussen O, Gregersen S, Hermansen K. (1990) The predictive capability of the glycaemic response to spaghetti in non-insulin-dependent and insulin-dependent diabetic subjects. *J Int Med* 228, 97–101.
 19. Rasmussen O. (1993) Day-to-day variation of the glycaemic response in subjects with insulin-dependent diabetes with standardized pre-meal blood glucose and prandial insulin concentrations. *Am J Clin Nutr* 57, 908–911.
 20. Rasmussen O. (1993) Dose-dependency of the glycaemic response to starch-rich meals in non-insulin-dependent diabetic subjects: studies with varying amounts of white rice. *Metabolism* 42, 214–217.
 21. Riccardi G, Clemente G, Giacco R. (2003) Glycaemic index of local foods and diets: the Mediterranean experience. *Nutrition Reviews* 61, S56–60.
 22. Sievppier JL, Jenkins AL, Whitham DL, Vuksan V. (2002) Insulin resistance: concepts, controversies, and role of nutrition. *Can J Diet Pract Res* 63, 20–32.
 23. Spraul M, Chantelau E, Schönbach AM, Berger M. (1988) Glycaemic effects of beer in IDDM patients. *Diabetes Care* 11, 659–661.
 24. Tews M, Schuderer U, Huth K. (1985) Die unterschiedliche Blutglukosewirkung verschiedener Kohlenhydrate beim Typ-2 Diabetiker. *Akt Ernähr* 10, 110–114.
 25. Zemlin C, Lüder W, Vetter K, Bruns W, Menzel R. (1989) Diät bei Diabetes mellitus. *Med Aktuell* 15, 49–52.