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(54) METHOD FOR DETERMINING THE GLYCAEMIC INDEX OF FOOD TO BE CONSUMED BY A PERSON

VERFAHREN ZUR BESTIMMUNG DES GLYKÄMISCHEN INDEXES VON LEBENSMITTELN, DIE VON EINER PERSON VERZEHRT WERDEN SOLLEN

PROCÉDÉ POUR DÉTERMINER L'INDICE GLYCÉMIQUE D'ALIMENTS DESTINÉS À ÊTRE CONSOMMÉS PAR UNE PERSONNE

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EP 3 270 165 B1

Description

FIELD OF INVENTION

[0001] The invention relates to the field of measurements for diagnostic purposes, in particular to measurements made to assess the effect of nutrient load upon human body. It can be used to develop simple personal technical means to monitor food intake based on human body response to consumed food.

BACKGROUND OF THE INVENTION

[0002] The glycemic index is a value that measures the variation of blood glucose (blood sugar) concentration by showing how fast and to what level the blood glucose concentration increases during intake of particular food. The glycemic index demonstrates the rate with which a certain food converts into glucose and infiltrates the blood.

[0003] The glycemic index of a particular food product is a relative notion. It is based on the index of pure glucose, which is assumed to be 100. The glycemic index of other food products ranges from 0 to 100 depending on the rate of its absorption by human body. Food products with a high glycemic index induce a rapid increase of blood glucose concentration. They are easily digested and absorbed by human body. Food products with a lower glycemic index cause a tempered increase of blood glucose concentration, because carbohydrates that they contain are digested more slowly.

[0004] The glycemic index is defined as a ratio of the area under the so-called glycemic response curve, which shows the variation of blood glucose concentration from the time a meal was taken until the moment it gets completely assimilated by human body, to the area under a similar glycemic curve that reflects the intake of pure glucose equal in amount to the amount of carbohydrates contained in a given food product.

[0005] The glycemic index usually refers to a certain food product. A series of tests are conducted to record the glycemic curve observed when a test subject consumes a food product with a known amount of glucose. In other experiments, the same test subject consumes an equal amount of pure glucose. As a result, average values of said ratios are obtained for the areas under glycemic curves. The glycemic index is usually expressed as a percentage.

[0006] For practical purposes, tables of glycemic indices are compiled for various food products. An exemplary table is shown in: Kaye Foster-Powell, Susanna HA Holt, and Janette C Brand-Miller. International table of glycemic index and glycemic load values: 2002. Am J Clin Nutr. - 2002, 76, 5-56.

[0007] However, such information on glycemic indices for particular food products can be insufficient for people, who, for example, follow a diet, in particular, monitor their glucose assimilation. Since the assimilation of food is individual for each person, they would like to know the glycemic index for specific food products they consume, rather than averaged data for separate products. In addition, they would like to know the glycemic index of the entire food they consume, consisting of a diverse set of food products, rather than the glycemic index of individual food products. And most important, an average consumer wants to know the glycemic index of food right after its assimilation instead of running experiments with food and pure glucose.

[0008] Initially, methods based on consumer's assessment of the effect of food-related carbohydrates using special tables based on experimental studies were widely used. Using the tables of glycemic indices of particular food products, a consumer can find a numerical value of the glycemic index, which characterizes the reaction of human body to carbohydrates incoming with meal. This calculation can be performed using remote databases that recognize the images of consumed food products transmitted from consumer's mobile devices. Such an approach provides only a rough evaluation of the glycemic index, because it refers to a specific food product, rather than to actually cooked food; besides the individual reaction of the body to this food is left out of consideration.

[0009] US 2005/0266385 A1 describes a method for monitoring the nutrition content information of consumables, and is intended to facilitate menu planning. The glycemic index of consumables is measured using the known glycemic indices for particular food products. This method does not provide for the evaluation of the glycemic index of food composed of different products.

[0010] WO 2008/009737 A2 describes a method for glycemic index evaluation based on glycemic indices for particular food products, said indices being transmitted from a remote database to consumer's personal device. Based on the glycemic indices of individual food products, which compose consumer's meal, and their amount, the glycemic index of entire meal is calculated.

[0011] The method closest to the claimed invention measures the glycemic index of consumed food generating a feedback as described in WO 2002/005702 A2. The core of the method is that the information on food to be taken at a meal, including its glycemic index and amount, is fed into computer beforehand. After the meal, blood glucose concentration is measured using one of the known methods. Based on the calculated values of blood glucose concentration, the glucose curve is modified and the glycemic index of the consumed food is adjusted in regard to a specific person. The resulting data are used to predict the blood glucose concentration and warn about its inadmissible increase, necessity to change eating behavior or undergo treatment. The article by Jenkins D.J.A. et al.: "Glycemic index of foods: a phys-

iological basis for carbohydrate exchange", Am. J. Clin. Nutrition, vol. 34, no. 3, March 1981, pages 362-366, discloses a method for measuring the glycemic index of foods and its use as a physiological basis for carbohydrate exchange.

[0012] The disadvantages of this method include the need to run multiple experiments in order to evaluate the glycemic index for each food product, which is inconvenient, since it requires multiple calculations and repetitive consumption of a certain product under the same conditions. This method cannot guarantee a stable, reproducible evaluation of the glycemic index for the same food product.

[0013] So, the need for a sufficiently fast and simple method of evaluating the glycemic index for a variety of food products, including meals of complex composition, is still actual. Additionally, this method needs to take into account the individual food assimilation features of a particular person and must provide sufficient accuracy.

SUMMARY OF THE INVENTION

[0014] The technical object that the claimed invention is supposed to solve is the development of a method for evaluating the glycemic index of food that produces effect immediately after the meal is consumed, enables the evaluation of the glycemic index for real multicomponent food and takes into account physiological peculiarities of a person.

[0015] An in vitro method for evaluating the glycemic index of human-consumed food in accordance with the claimed inventionthat includes the following steps:

[0016] non-invasively measurement of blood glucose concentration in the human in time, at least from the onset of an increase of a blood glucose concentration caused by food intake until the blood glucose concentration reaches its peak,

[0017] based on the above measurement, time interval Δt from the onset to said peak of the blood glucose concentration is evaluated and the maximum increase of blood glucose concentration ΔG_{max} over the given time period Δt is specified,

[0018] here, the glycemic index of consumed food is defined as a ratio of the maximum increase of blood glucose concentration ΔG_{max} to the maximum increase in blood glucose concentration upon intake of pure glucose equal in amount to carbohydrate content of the consumed food; said ratio being proportional to the product of ΔG_{max} by Δt.

[0019] The inventors have established experimentally that the area under the glycemic response curve *G(t)* within the limits between the onset of food-related blood glucose concentration increase and peak of glucose concentration G_{max}, when calculated without the initial value of glucose concentration taken into account, is proportional, with insignificant assumptions, to the amount of carbohydrates C_{sum} that the consumed food contains. Given an almost linear nature of the blood glucose concentration increase over a given time interval Δt, the area under the glycemic response curve within the above-mentioned time limits and, as stated previously, without initial blood glucose concentration taken into account, would be equal to:

$$S = 0{,}5 \cdot \Delta t \cdot \Delta G_{\max},$$

where ΔG_{max} the maximum increase of glucose concentration over time Δt.

[0020] In other words, the carbohydrate content of the consumed food is:

$$C_{sum} = K \cdot \Delta t \cdot \Delta G_{\max}, \qquad (1)$$

where K is a proportionality factor, the magnitude and dimension of which are determined experimentally with the dimensions that were used for ΔG_{max} and Δt taken into account.

[0021] In reference to the maximum increase of blood glucose concentration, caused by pure glucose intake *GI* equal in its amount to carbohydrate content C_{sum} of the consumed food (let us denote the increase as $\Delta G_{\max}^{(gl)}$), it can be estimated based of known data. For example, the data on blood glucose concentration increase following the intake of pure glucose can be found in:

[0022] Jennie C Brand-Miller, Karola Stockmann, Fiona Atkinson, Peter Petocz, and Gareth Denyer. Glycemic index, postprandial glycemia, and the shape of the curve in healthy subjects: analysis of a database of more than 1000 foods. Am J Clin Nutr. 2009, 89, 97-105.

[0023] R. M. Elliott, L. M. Morgan, J. A. Tredger, S. Deacon, J. Wright, and V. Marks. Glucagon-like peptide-1(7-36) amide and glucose-dependent insulinotropic polypeptide secretion in response to nutrient ingestion in man: acute post-prandial and 24-h secretion patterns. J Endocrinol. - 1993, 138, 159-166.

[0024] Finally, the target value of glycemic index *GI* of human-consumer food is defined as a ratio of ΔG_{max} to $\Delta G_{\max}^{(gl)}$, namely:

$$Gl = \left(\frac{\Delta G_{\max}}{\Delta G_{\max}^{(gl)}} \right) \times 100 \qquad (2)$$

[0025] Here, said ratio, when multiplied by 100, transforms the obtained value of the glycemic index to its conventional form.

[0026] Thus, the method described in the claimed invention makes it possible (1) to evaluate the glycemic index of consumed food having an arbitrary (multicomponent or complex) composition, i.e., of real food, and (2) to avoid complex calculations needed for separate assessment of food products comprising the consumed meal, evaluation of their glycemic indices and e total value of the glycemic index of the entire consumed meal. In reference to the measurement of blood glucose concentration *G(t),* current methods, primarily, non-invasive ones, (1) afford opportunity to make real time measurements at a frequency providing a reliable identification of a point in time when the growth of food-related blood glucose concentration stops, and, (2) are quite comfortable for users.

[0027] Experiments demonstrated that the above assumptions related to the evaluation of carbohydrate content C_{sum} of the consumed food through $\Delta G_{\max}$ and Δt specified on the basis of blood glucose measurements *G(t)* may introduce errors of several percent into the results of glycemic index evaluation *Gl,* which is considered quite acceptable for such measurements.

[0028] In a particular case of measuring carbohydrate content C_{sum} of the consumed food, in grams, and specifying said time interval Δt, in min, and said maximum increase of blood glucose concentration $\Delta G_{\max}$, in mmol/l, the proportionality factor K in equation (1) is selected within 0.35 g/min·mmol/l to 0.60 g/min·mmol/l range. The above values have been obtained experimentally by the inventors.

[0029] Specifically, when implementing this method using said quantity dimensions of measured values $\Delta G_{\max}$, Δt and factor value K, the maximum increase of blood glucose concentration $\Delta G_{\max}^{(gl)}$ in case of pure glucose intake *Gl* equal in amount to carbohydrate content C_{sum} of the consumed food can be determined using the plot shown in Fig.1. This plot is also based on experiments.

[0030] As it was noted above, non-invasive measurements are preferable for the evaluation of blood glucose concentration.

BRIEF DESCRIPTION OF DRAWINGS

[0031] The invention is illustrated by the following graphic materials.

Fig.1 shows the dependence of maximum increase of blood glucose concentration $\Delta G_{\max}^{(gl)}$ related to the intake of pure glucose *Gl,* said dependence being experimentally determined by the inventors and used for implementing the proposed method.

Fig. 2 shows blood glucose concentration measurement results for the first implementation of the invention.

Fig. 3 shows blood glucose concentration measurement results for the second implementation of the invention.

Fig. 4 shows blood glucose concentration measurement results for the third implementation of the invention.

DISCLOSURE OF INVENTION

[0032] The method according to the present invention is implemented as follows. Measurement of blood glucose concentration *G(t)* starts when food intake begins. Any suitable methods and devices can be used for this purpose, with non-invasive methods being preferable, since the method proposed by the claimed invention involves repeated measurements of blood glucose concentration, and non-invasive methods are the most comfortable for humans. The measurements are performed continuously or over certain periods of time, which provides a sufficient reliably of evaluating changes in blood glucose concentration over time t. Due to food intake, blood glucose concentration of the consumer starts growing and reaches its maximum value after a certain period of time. Thereafter, the glucose concentration starts to decrease, which gives a signal to stop the measurement.

[0033] Based on the results of measurements, time interval Δt (in min) from the beginning of food-related increase of blood glucose concentration until its peak is reached, as well as the maximum increase of glucose concentration $G_{\max}$ (in mmol/1) over a given period of time Δt are evaluated.

[0034] Further on, carbohydrate content C_{sum} (in grams) of the food consumed during a meal is calculated using

formula (1), with the proportionality factor K taken to be 0.525 g/min·mmol/l, which represents the average value for a healthy adult (see examples below).

[0035] Based on the specific value C_{sum} and using the plot shown in Fig. 1, the maximum food-related increase of glucose concentration $\Delta G_{\max}^{(gl)}$ caused by an intake of pure glucose *GI* equal in amount to C_{sum} is determined. This plot is based on experiments run by the authors of the method in the process of its development. The plot can be substituted either with a mathematical relationship representing an approximation of said curve, or with available experimental data.

[0036] Finally, the glycemic index *GI* of consumed food is determined from equation (2) as a ratio of the maximum increase of blood glucose concentration $\Delta G_{\max}$ to value $\Delta G_{\max}^{(gl)}$, which represents the maximum increase in blood glucose concentration in case of pure glucose intake.

[0037] As it was said, the method proposed in the claimed invention makes it possible to evaluate the glycemic index for specific food products, as well as their combination consumed during a meal, i.e., the glycemic index of mixed food load. The latter is of major interest for practical glycemic index evaluation, since the food consumed in everyday life is composed of various products.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0038] A number of experiments were undertaken to test the feasibility of the proposed method and to achieve said results. At each experiment, a volunteer received a dosed nutritional load consisting of different food products. In accordance with the claimed invention, volonteer's blood glucose concentration was measured from the beginning of the meal until the food-related growth of glucose concentration stopped. The glucose concentration was measured using the non-invasive method described in Application PCT/ RU2013/000144 (International Publication Number WO 2013/125987). The measurements were made in 1 minute periods, with the results of measurements confirmed by standard invasive method with blood samples taken every 15 minutes. The results of the discrete measurements were recorded, and curves showing the relation of time t versus blood glucose concentration G were plotted using approximation (see Fig. 2 - Fig. 4).

[0039] Based on the plotted curves, time interval Δt, within which blood glucose concentration growth G was observed, and maximum increase of glucose concentration $\Delta G_{\max}$ over said time interval were estimated. Using equation (1), carbohydrate content C_{sum} of the consumed food was calculated after which, drawing on the plot shown in FIG. 1, the maximum increase of blood glucose concentration $\Delta G_{\max}^{(gl)}$ was evaluated for a case of pure glucose intake *GI*; and the glycemic index of the consumed food was calculated using equation (2).

[0040] To confirm the results, a known method for calculating the total (or cumulative) glycemic index of mixed food was used. This method is described in book: The glucose revolution: the authoritative guide to the glycemic index, the groundbreaking medical discovery / by Jennie Brand-Miller at al. - Marlow & Company, New York, 1999, p. 33. In this method, carbohydrate content (in grams) of the consumed food is calculated, and, based thereon, the proportion of carbohydrate content in a given food product in the total nutritional load is determined. Thereafter, the glycemic index of each food product is multiplied by its specific carbohydrate content proportion, with the results are summed up to yield the total glycemic index of the nutritional load *GI,* or:

$$GI = \sum_{j=1}^{n} P_j \cdot GI_j ,$$

where: P_j is the carbohydrate content of *j*-th food product;

GI_j is the glycemic index of *j*-th food product;

n is the number of individual food products that make up the mixed meal.

[0041] The glycemic indices of individual food products were taken from tables published in: Kaye Foster-Powell, Susanna HA Holt, and Janette C Brand-Miller. International table of glycemic index and glycemic load values: 2002. Am J Clin Nutr. - 2002, 76, 5-56.

[0042] At the end of the experiments, the deviation of the total glycemic index value of the nutritional load (consumed food), obtained by the proposed method, from the cumulative glycemic index of the same nutritional load calculated using the control method was evaluated.

EXAMPLE 1

[0043] Volunteer: a female, age 50, height 164 cm, weight 63 kg.
[0044] Composition of nutritional load:

Cream puff - 65 g (carbohydrates - 39.0 g, glycemic index (GI) - 75);

Eclair - 69 g (carbohydrates - 20.7 g, GI - 75);

Tea - 200 ml, with granulated sugar - 10 g (carbohydrates - 10 g, GI - 70).

[0045] Table 1.1 below shows the initial data and calculated value of consumed food glycemic index obtained using the confirmatory method.

Table 1.1.

Food composition	Carbohydrates, g	Carbohydrate content	Product GI	Contribution to mixed nutritional load GI
Cream puff	39.0	0.56	75	0.56-75 = 42.0
Eclair	20.7	0.30	75	0.30-75 = 22.5
Tea with granulated sugar	10.0	0.14	70	0.14-70 = 9.8
Total	69.7	1.0		74.3

[0046] The calculation of glycemic index in accordance with the claimed invention yielded the following results.
[0047] Fig. 2 shows a plot of blood glucose concentration values G measured from the beginning of food intake, which enables the evaluation of:

time lapse Δt = 37 minutes, during which an increase in glucose concentration was observed, and

maximum increase of glucose concentration ΔG_{max} = 3.4 mmol/l over said time period Δt.

[0048] Using equation (1), the carbohydrate content C_{sum} of the food consumed during a meal was calculeted and found equal to C_{sum} = 66.0 g, with factor K assumed to be 0.525 g/min • mmol/l.
[0049] The maximum increase of blood glucose concentration that would occur in case of pure glucose intake was determined from the plot shown in Fig. 1 and found $\Delta G_{\max}^{(gl)} = 4.6$ mmol/l.
[0050] The final value of the glycemic index of all consumed food was calculated using equation (2) and found GI = 72.3.
[0051] For convenience, the values of consumed food glycemic index calculated in accordance with the claimed invention are summarized in Table 1.2.

Table 1.2.

Δt, minutes	ΔG_{max}, mmol/l	C_{sum}, g	$\Delta G_{\max}^{(gl)}$, mmol/l	GI
37	3.4	66.0	4.6	72.3

[0052] The relative deviation of food GI calculated in accordance with the claimed invention compared to the results obtained by calculating food GI using confirmatory method was 2.8%.

EXAMPLE 2

[0053] Volunteer: a male, age 58, height 174 cm, weight 84 kg.
[0054] Nutritional load composition:

carbonade - 100 g (carbohydrates - 0.0 g);

wheat bread - 54 g (carbohydrates - 40.9 g, *GI* - 85);

butter - 20 g (carbohydrates - 0.18 g, *GI - 70);*

coffee - 160 ml with sugar -10 g (carbohydrates - 10 g, *GI* - 70).

[0055] Table 2.1 below shows the initial data and calculated value of consumed food glycemic index obtained using the confirmatory method.

Table 2.1.

Food composition	Carbohydrates, g	Carbohydrate content	Product *GI*	Contribution to mixed nutritional load *GI*
Wheat bread	40.9	0.80	85	0.80-85 = 68.0
Butter	0.18	0.005	70	0.05-70 = 0.35
Coffee with granulated sugar	10.0	0.195	70	0.195-70 = 13.65
Total	51.1	1.0		82.1

[0056] The calculation of glycemic index in accordance with the claimed invention yielded the following results.
[0057] Fig. 3 shows a plot of blood glucose concentration G from the beginning of the meal, while the values of glycemic index determined in accordance with the claimed invention are summarized in Table 2.2.

Table 2.2

Δt, minutes	ΔG_{max}, mmol/l	C_{sum}, g	$\Delta G_{\max}^{(gl)}$, mmol/l	*GI*
38	3.1	61.8	4.1	75.6

[0058] The relative deviation of food *GI* calculated in accordance with the claimed invention compared to the results obtained by calculating food *GI* using confirmatory method was 7.7%.

EXAMPLE 3

[0059] Volunteer: a female, age 22, height 162 cm, weight 53 kg.
[0060] Nutritional load composition:

Kievskaya cutlet - 117 g (carbohydrates - 30.4 g, *GI* - 85);

Boiled buckwheat - 125 g. (carbohydrates - 31.2 g, *GI* - 40);

Coffee with granulated sugar - 160 ml (carbohydrates - 5 g, *GI* - 70).

[0061] Table 2.1 below shows the initial data and calculated value of consumed food glycemic index obtained using the confirmatory method.

Table 3.1

Food composition	Carbohydrates, g	Carbohydrate content	Product *GI*	Contribution to mixed nutritional load *GI*
Kievskaya cutlet	30.4	0.46	85	0.46-85 = 39.1
Boiled buckwheat	31.2	0.47	40	0.47-40 = 18.8
Coffee with granulated sugar	5.0	0.07	70	0.07-70 = 4.9

(continued)

Food composition	Carbohydrates, g	Carbohydrate content	Product *GI*	Contribution to mixed nutritional load *GI*
Total	66.7	1.0		62.8

[0062] The calculation of glycemic index in accordance with the claimed invention yielded the following results.

[0063] Fig. 4 shows a plot of blood glucose concentration G from the start of the meal, while the results of determining the glycemic index of the present invention are summarized in Table 3.2.

Table 3.2.

Δt, minutes	ΔG_{max},mol/l	C_{sum}, g	$\Delta G_{\max}^{(gl)}$, mmol/l	*GI*
39	3.25	66.5	4.64	70.0

[0064] The relative deviation of food *GI* calculated in accordance with the claimed invention compared to the results obtained by calculating food *GI* using confirmatory method was 4.9%.

[0065] Tests proved that the method proposed in the claimed invention can provide an estimate of the glycemic index of mixed or, in other words, real food assimilated by a human body. The glycemic index evaluation performed using this method takes into consideration the peculiarities of particular food assimilation by a person. Moreover, the resulting glycemic index of consumed food is obtained immediately after the food intake ends.

[0066] The proposed method is intended primarily for determining the glycemic index of a mixed food assimilated by a healthy human and can be used for developing various devices and systems for automatic monitoring of carbohydrate content of human food.

Claims

1. An in vitro method for measuring a glycemic index GI of food of a multicomponent composition consumed by a human, the method comprising:

   non-invasively measuring a blood glucose concentration in the human (G(t) from an onset of increase of a blood glucose concentration caused by the food intake until the blood glucose concentration reaches its peak;
   determining (i) a time interval Δt from the onset to the peak of the blood glucose concentration (ii) a maximum increase of a blood glucose concentration ΔG_{max} over the time period Δt, and (iii) a carbohydrate content $C_{sum} = K \cdot \Delta t \cdot \Delta G_{max}$ wherein a proportionality factor K is selected within a 0.35 g/min·mmol/l to 0.6 g/min·mmol/l range, wherein the amount of carbohydrates C_{sum} of the food is measured in grams, said time period Δt is measured in minutes, and said maximum increase of blood glucose concentration $\Delta Gmax$ is measured in mmol/l; and
   determining the glycemic index GI of the food as a ratio $\Delta G_{max} / \Delta G^{(gl)}{}_{max}$, wherein $\Delta G^{(91)}{}_{max}$ is a maximum increase of a blood glucose concentration upon intake of pure glucose in an amount equal to the carbohydrate content C_{sum}.

2. The method of claim 1, wherein the proportionality factor is K = 0,525 g/min·mmol/l.

3. The method of claim 2, wherein the food included 51.1 - 69.7 g of carbohydrates.

Patentansprüche

1. In-vitro-Verfahren zum Messen eines glykämischen Index GI von Lebensmitteln einer von einem Menschen verzehrten Mehrkomponenten-Zusammensetzung, wobei das Verfahren umfasst:

   nicht-invasives Messen einer Blutzuckerkonzentration im Menschen G(t) ab dem Beginn eines Anstiegs einer Blutzuckerkonzentration, der durch die Nahrungsaufnahme verursacht wird, bis die Blutzuckerkonzentration

ihren Höhepunkt erreicht
Bestimmen (i) eines Zeitintervalls Δt vom Beginn bis zum Höhepunkt der Blutzuckerkonzentration, (ii) eines maximalen Anstiegs einer Blutzuckerkonzentration ΔG_{max} über den Zeitraum Δt, und (iii) eines Kohlenhydratgehalts $C_{sum} = K \cdot \Delta t \cdot \Delta G_{max}$, wobei ein Proportionalitätsfaktor K innerhalb eines Intervalls von 0,35 g/min·mmol/l bis 0,6 g/min mmol/l ausgewählt wird; und
Bestimmen des glykämischen Index GI des Lebensmittels als ein Verhältnis $\Delta G_{max} / \Delta G^{(gl)}_{max}$, wobei $\Delta G^{(gl)}_{max}$ eine maximale Erhöhung einer Blutzuckerkonzentration bei Aufnahme von reiner Glucose in einer Menge ist, die dem Kohlenhydratgehalt C_{sum} entspricht.

2. Verfahren nach Anspruch 1, wobei der Proportionalitätsfaktor K = 0,525 g/min·mmol/l ist.

3. Verfahren nach Anspruch 2, wobei das Lebensmittel 51,1 bis 69,7 g Kohlenhydrate enthalten hat.

Revendications

1. Procédé in vitro pour mesurer un indice glycémique IG d'aliments d'une composition à plusieurs composants consommé par un être humain, le procédé comprenant:

mesurer de manière non invasive une concentration de glucose sanguin dans le G(t) humain à partir d'un début d'augmentation d'une concentration de glucose sanguin provoquée par la prise alimentaire jusqu'à ce que la concentration de glucose sanguin atteigne son pic;
déterminer (i) un intervalle de temps Δt entre le début et le pic de la concentration de glucose dans le sang, (ii) une augmentation maximale d'une concentration de glucose dans le sang ΔG_{max} sur la période de temps Δt, et (iii) une teneur en glucides $C_{sum} = K \cdot \Delta t \cdot \Delta G_{max}$ dans laquelle un facteur de proportionnalité K est sélectionné dans un intervalle de 0,35 g/min·mmol/l à 0,6 g/min·mmol/l; et
détermination de l'indice glycémique GI de l'aliment en tant que rapport $\Delta G_{max}/\Delta G^{(gl)}_{max}$, où $\Delta G^{(gl)}_{max}$ est une augmentation maximale d'une concentration de glucose sanguin lors de l'ingestion de glucose pur en une quantité égale à la teneur en glucides Csum.

2. Procédé selon la revendication 1, dans lequel le facteur de proportionnalité est K = 0,525 g/min·mmol/l.

3. Procédé selon la revendication 2, dans lequel l'aliment comprenait 51,1 - 69,7 g de glucides.

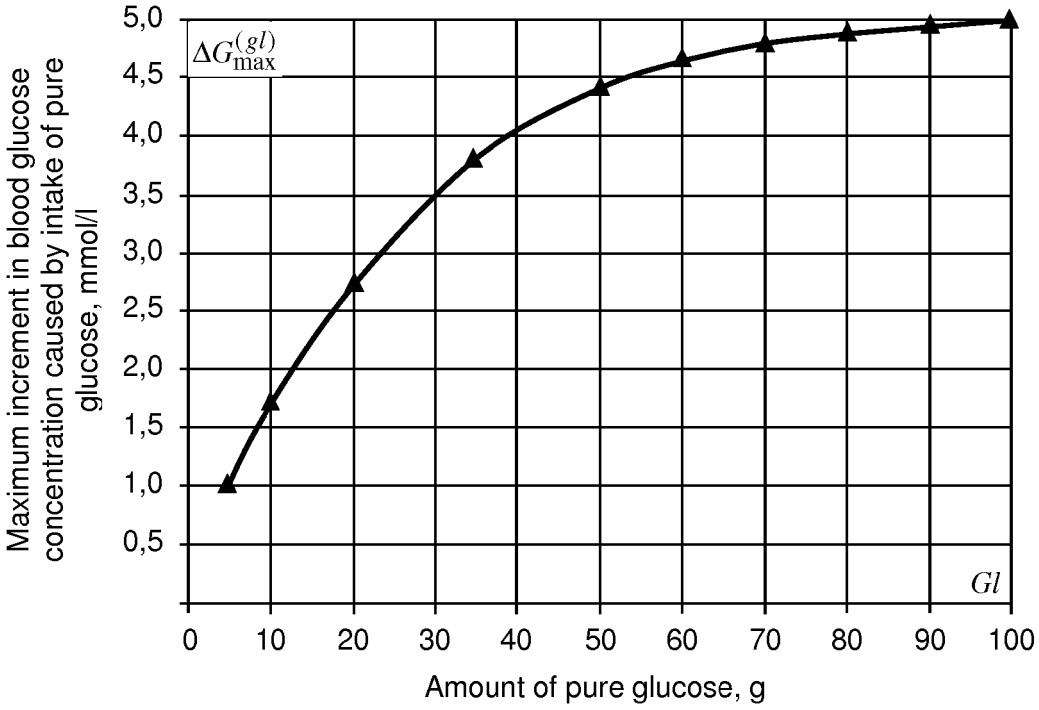
Maximum increment in blood glucose concentration caused by intake of pure glucose, mmol/l
$\Delta G_{max}^{(gl)}$
5,0
4,5
4,0
3,5
3,0
2,5
2,0
1,5
1,0
0,5
Gl
0
10
20
30
40
50
60
70
80
90
100
Amount of pure glucose, g

Fig. 1

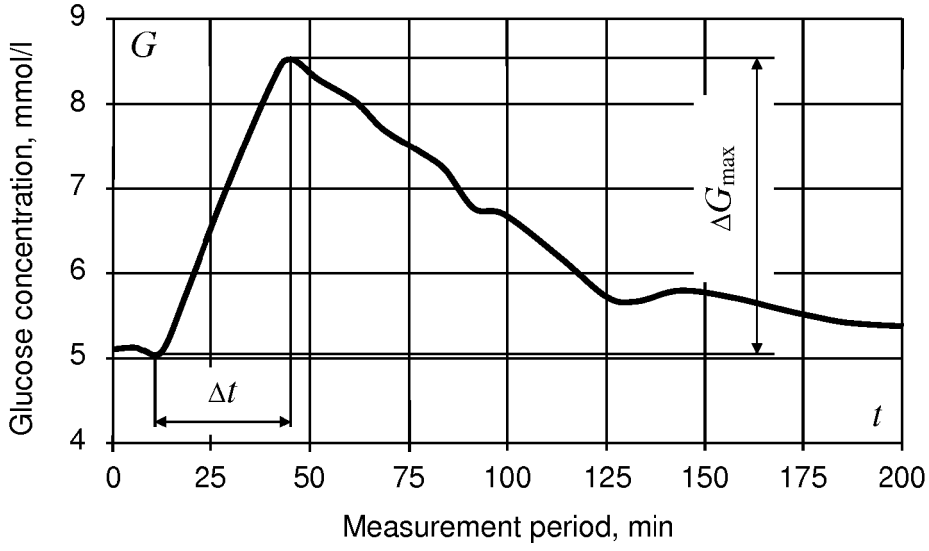
Glucose concentration, mmol/l
G
9
8
7
6
5
4
ΔG_{max}
Δt
t
0
25
50
75
100
125
150
175
200
Measurement period, min

Fig. 2

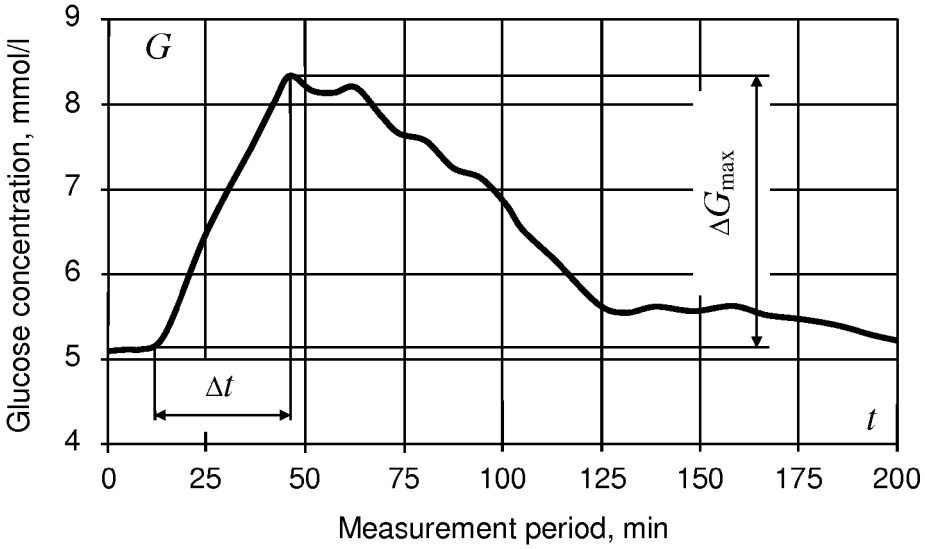
G
9
8
7
6
5
4
0
25
50
75
100
125
150
175
200
Glucose concentration, mmol/l
Measurement period, min
ΔG max
Δt
t

Fig. 3

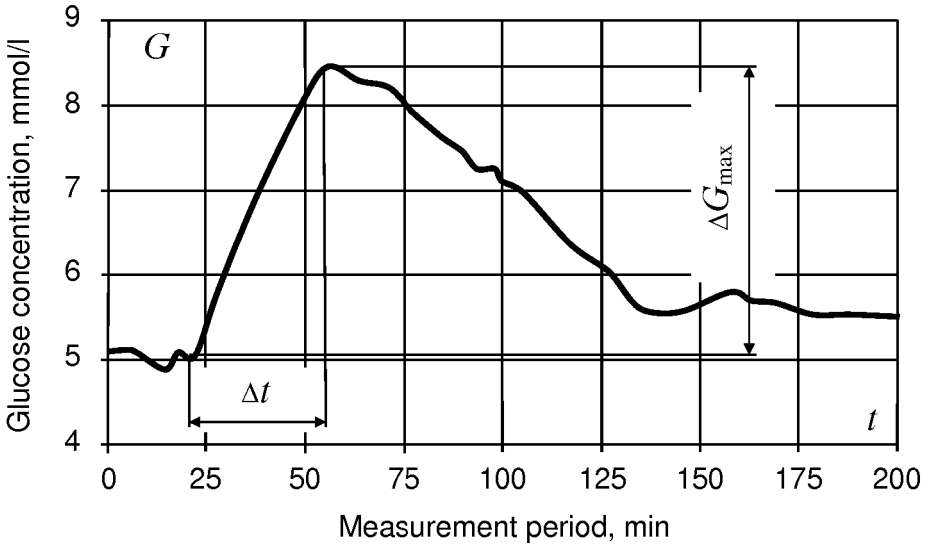
G
9
8
7
6
5
4
0
25
50
75
100
125
150
175
200
Glucose concentration, mmol/l
Measurement period, min
ΔG max
Δt
t

Fig. 4

REFERENCES CITED IN THE DESCRIPTION

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