GLYCAEMIC AND INSULINAEMIC RESPONSES TO A NEW HYDROGENATED STARCH HYDROLYSATE IN HEALTHY AND TYPE 2 DIABETIC SUBJECTS

S.W. RIZKALLA (1), J. LUO (1), D. WILS (2), F. BRUZZO (1), G. SLAMA (1)

SUMMARY - Background: Industrialists are searching for a sugar replacement in confectioneries such as hard candies, gum and chocolate. Lycasin® HBC is a suitable candidate. Nevertheless, no information on its plasma glucose and insulin responses exists. Therefore, we aimed to evaluate the glycaemic and insulinaemic indices of Lycasin® HBC in healthy subjects and in subjects with type 2 diabetes mellitus.

Methods: Six healthy and six type 2 diabetic men participated in the study. Each subject absorbed, after an overnight fast, a challenge of either 50 g of glucose or 50 g of Lycasin® HBC using a randomised double-blind crossover design. Blood samples for measuring plasma glucose and insulin concentrations were collected during a 3 hour period.

Results: The calculated glycaemic index of Lycasin® HBC was 47 ± 10% in healthy subjects and 25 ± 6% in patients with type 2 diabetes mellitus. The insulinaemic index of Lycasin® HBC was 23 ± 4% and 39 ± 14%, respectively. As glucose levels oscillate in a very limited range in normal healthy subjects, the insulinaemic index must be considered here. On the other hand, it is the glycaemic rather than the insulinaemic index that must be assessed in diabetic subjects due to impairment of insulin secretion.

Conclusions: The tested Lycasin® HBC showed a low insulinaemic index in healthy subjects (23 ± 4%) and a low glycaemic index (25 ± 6%) in type 2 diabetic patients. Thus, it might be considered as an interesting sucrose substitute in confectionery for individuals with or without diabetes.

Key-words: Lycasin® HBC, glycaemic index, insulinaemic index, healthy subjects, type 2 diabetic subjects.

RE ´SUMÉ - Réponses glycémiques et insulinémiques à un sirop de maltitol, le Lycasin® HBC, chez des sujets normaux et chez des sujets diabétiques de type 2.

Contexte : Il s’agit de déterminer les index glycémique et insulinémique d’un produit dérivant d’hydrolysats d’amidon hydrogéné : le LYCASIN®HBC (LB 2212).

Méthodes : Deux populations de 6 sujets normaux et de 6 diabétiques de type 2 ont participé à la réalisation de cette étude. Chaque sujet a absorbé dans un ordre aléatoire une charge équivalente à 50 g de glucide soit sous forme de D-glucose soit sous forme d’une solution LYCASIN®HBC testé dans l’eau (volume final : 150 ml). Chaque test est effectué à une semaine d’intervalle. Les prélèvements sanguins ont été effectués durant 3 heures.

Résultats : L’index glycémique calculé du LYCASIN®HBC était 47 ± 10 % chez les sujets normaux et 25 ± 6 % chez les sujets diabétiques de type 2. L’index insulinaémique du LYCASIN®HBC chez les sujets normaux et chez les sujets diabétiques, étaient respectivement 23 ± 4 % et 39 ± 14 %.

Comme les valeurs de glycémies varient dans une très faible fourchette chez le sujet normal, l’index insulinaémique donne une meilleure mesure de la réponse physiologique pour une telle population. Par contre chez les sujets diabétiques, l’utilisation de l’index glycémique donne une meilleure information que l’index insulinémique en raison d’un défaut de l’insulinosécrétion.

Conclusions : Le LYCASIN®HBC a montré un index insulinémique bas chez les sujets normaux (23 ± 4 %) et un index glycémique bas (25 ± 6 %) chez les sujets diabétiques. Dans cette optique, le LYCASIN®HBC est un produit intéressant à considérer en confiserie, comme édulcorant, chez le sujet sain et chez le sujet diabétique.

Mots-clés : LYCASIN® HBC, index glycémique, index insulinémique, sujet sain, sirop de maltitol, diabète.

High postprandial plasma glucose and insulin excursions are assumed to be independent predictors of risk for atherosclerotic diseases. Epidemiological evidence [1] shows that the relationship between plasma glucose concentration and cardiovascular disease extends well below the glucose level defined for diabetes and even that for impaired glucose tolerance. Recently, attention has been focused on finding the carbohydrate that elicits low postprandial plasma glucose and insulin levels.

Differences in metabolic responses to carbohydrates can be classified by their glycaemic index (GI) which compares the levels of plasma glucose after equal carbohydrate portions of foods and ranks them relative to a standard (glucose [2] or white bread [3, 4]).

For sugars and sweeteners, attention has been paid to sugar-alcohols that have physical and chemical properties similar to sucrose. Because of their bulking, sweetening and non-cryogenic properties, they can be used as sugar replacers in hard candies. Lycasin® HBC is a new sugar alcohol. It is obtained by hydrogenation of starch hydrolysate containing 50-55% maltitol, 5-8% sorbitol and 35-40% hydrogenated saccharides. It might be an interesting sweetening agent for hard candies. There is no available information, however, concerning its postprandial glycaemic and insulinaemic responses. Therefore, the aim of the present study was to evaluate the glycaemic and insulinaemic indices of Lycasin® HBC in healthy subjects and in subjects with type 2 diabetes mellitus.

**SUBJECTS AND METHODS**

**Subjects**

Six healthy men and six men with type 2 diabetes mellitus, aged 20-60 years, were included in the study. The clinical and biological characteristics of subjects are given in Table I. The ethical committee of the Hôtel-Dieu Hospital approved the protocol and each volunteer gave a written informed consent. Subjects with abnormal digestive, hepatic or renal functions as determined by past history, physical examination, blood cell count and standard biochemical blood profile were excluded. The 6 diabetic patients were selected on the basis of having fasting plasma glucose of > 7.00 mmol/L. They were treated with diet alone and/or oral antidiabetic agents (sulfonylurea and/or metformine). All subjects kept the same treatment during the experimental period. On the study day, patients took their respective antidiabetic treatment as usual.

<table>
<thead>
<tr>
<th>TABLE I. Clinical characteristics of subjects.</th>
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<tbody>
<tr>
<td>Non-diabetic subjects (n = 6)</td>
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<tr>
<td>Age (yr)</td>
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<tr>
<td>BMI (%)</td>
</tr>
<tr>
<td>Fasting glycaemia (mmol/L)</td>
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<td>HbA1c (%)</td>
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<tr>
<td>Plasma cholesterol (mmol/L)</td>
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<td>Plasma triglycerides (mmol/L)</td>
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Results are shown as means ± SEM.

**Methods**

**The tested product**

The syrup tested was Lycasin® HBC (lab 2212, Roquette, Lestrem, France), obtained by hydrogenation of starch hydrolysates containing dextrose, maltose and oligo-maltosides. The final product contained 50-55% maltitol, 5-8% sorbitol and 35-40% hydrogenated oligo-saccharides.

Glucose was used as a standard in the determination of glycaemic and insulinaemic indices. For each test, a challenge of either 50 g of Lycasin® HBC or 50 g of glucose was diluted in a final volume of 150 ml of water.

**Experimental design and method**

The study followed a randomised double-blind crossover design. After an overnight fast, each subject absorbed a challenge of either 50 g of glucose or 50 g of Lycasin® HBC, in a random order with an interval of one week. Blood samples were collected before the challenge (time – 30 min and time 0) and then at 15, 30, 60, 90, 120, 180 min to measure plasma glucose and insulin concentrations.

Plasma glucose was measured by the glucose oxidase method with a glucose analyser (Beckman Fullerton, Palo Alto, CA). Plasma insulin was determined by a radioimmunoassay (RIA Diagnostic Pasteur, Marnes la Coquette, France). The antiserum used in the test showed a cross-reactivity of 100% with human insulin and of 40% with proinsulin.

Glycaemic and insulinaemic indices of Lycasin® HBC were calculated as previously described [5, 6]. Areas under curves were calculated for plasma glucose and insulin concentrations according to the trap-
ezoidal method [5]. Glycaemic index was the ratio of the area under the curve for plasma glucose measured during the Lycasin® HBC challenge to that during the glucose challenge. The insulinaemic index was calculated in the same way.

### STATISTICAL ANALYSIS

All the statistics were carried out with Statview 512 + software program (Brainpower Inc, Calabasas, CA, USA). The glucose and insulin responses within the same group of individuals (between the two sugars or between baseline values with those observed at the different times of oral tests) were compared by repeated measurements ANOVA followed by Fisher’s post-hoc least significance difference (PLSD) test. To evaluate differences between diabetic and healthy subjects, unpaired student’s t-test was used. Results are given as mean ± SEM. Differences were considered significant when p < 0.05.

### RESULTS

#### In healthy subjects

Figure 1A shows the average glycaemic values during the glucose and Lycasin® HBC challenges. Fasting plasma glucose concentrations were similar before the glucose (4.47 ± 0.22 mmol/L) and the Lycasin® HBC charge (4.72 ± 0.17 mmol/L). Postprandial glycaemic peaks appeared 30 minutes after the challenge and reached the moderate levels of 6.06 ± 0.39 and 5.44 ± 0.39 mmol/L for glucose and Lycasin® HBC, respectively (p < 0.05). This difference was found also at 60 min (p < 0.05). After the glucose and the Lycasin tests, plasma glucose responses increased at 15, 30 min when compared to baseline values for each test (p < 0.001). The calculated glycaemic index (GI) of Lycasin® HBC was 47 ± 10% in healthy subjects.

Fasting plasma insulin concentrations were also similar before the glucose (91 ± 14 pmol/L) and the Lycasin® HBC challenges (70 ± 7 pmol/L). Postprandial insulinaemic peaks appeared 30 minutes after the challenge and reached the levels of 392 ± 105 and 154 ± 35 pmol/L for glucose and Lycasin® HBC, respectively (p < 0.05) (Fig. 1B). Moreover, insulin responses after Lycasin® HBC were also lower than that of glucose charge at 15, 60 and 90 min (p < 0.05). Insulin responses increased significantly during the two tests at 15, 30 and 60 min compared to baseline values during each test (p < 0.001). The calculated insulinaemic index (II%) of Lycasin® HBC was 23 ± 4% in healthy subjects.

#### In type 2 diabetic subjects

Fasting plasma glucose concentrations were elevated (when compared to healthy subjects, p < 0.01) and averaged 8.56 ± 0.61 and 10.06 ± 0.94 mmol/L at time 0 of the glucose and Lycasin® HBC charges respectively (Fig. 2A). Postprandial glycaemic peaks appeared 60 min after the challenge and reached 16.22 ± 1.11 and 12.39 ± 0.83 mmol/L for glucose (p < 0.001) and Lycasin® HBC respectively (p < 0.05) (Fig. 2A). Moreover plasma glucose values were lower at 90, 120 and 180 min after Lycasin than after glucose challenge (p < 0.05). The plasma glucose responses to the glucose challenge increased at all the studied times when compared to the baseline value (p < 0.0001). However, plasma glucose responses after Lycasin was higher at 30 and 60 min than baseline value. The calculated GI of Lycasin® HBC was 25 ± 6% in type 2 diabetic subjects.

Fasting plasma insulin concentrations averaged 133 ± 7 and 196 ± 28 pmol/L at time 0 of the glucose and Lycasin® HBC challenges respectively (Fig. 2B). Postprandial insulinaemic peaks appeared 90 minutes after the challenge and reached 336 ± 63 and 245 ± 14 pmol/L for glucose and Lycasin® HBC, respectively (p < 0.05) (Fig. 2B). Plasma insulin responses increased after the glucose challenge at 60, 90 and 120 min compared to baseline value (p < 0.0001). After the Lycasin challenge, these responses at 90 and 120 min were higher than the baseline values (p < 0.001).The calculated insulinaemic index of Lycasin® HBC was 39 ± 14% in type 2 diabetic subjects.

### DISCUSSION

The glycaemic index (GI) of the new Lycasin® HBC determined in the present study was 47 ± 10% in healthy subjects. However, the physiological relevance of the glycaemic index for ranking in normal healthy subjects has been questioned, as healthy subjects can always maintain their plasma glucose levels within a very narrow range. This equilibrium masks the differences in plasma glucose responses. In these type of subjects, plasma insulin responses are more relevant than glycaemic responses. For this reason, the concept of insulinaemic index was introduced. In fact, Lycasin showed a low insulinaemic index of 23 ± 4%.

Because diabetic patients have impaired pancreatic insulin secretion, it is the glycaemic index that has to be taken into consideration and not the insulinaemic index. Indeed, in diabetic patients, the glycaemic index of Lycasin was 25% which was similar to the insulinaemic index in normal subjects. Therefore, Lycasin® HBC (lab 2212) is a sugar with a very low glycaemic index in diabetic subjects and a very low insulinaemic index in normal subjects.

Compared to traditional sweeteners, Lycasin® HBC, the hydrogenated starch hydrolysate used in the present study, has much lower glycaemic and insulinaemic indices than sucrose and fructose. This difference in glycaemic and insulinaemic responses was maintained when sucrose, fructose or isomalt (which
has a similar composition to Lycasin® HBC) were integrated into milk chocolate as demonstrated in a previous study in type 2 diabetic subjects [7].

In diabetic subjects, the glycaemic index of Lycasin® HBC is similar to the glycaemic index of maltitol (Maltisorb®, GI: 25%), but lower than that of Lycasin 80/55 (80%: dry material, 55% maltitol, GI%: 46%), non-published data. This might be explained by the fact that the new Lycasin® HBC contains higher proportion of hydrogenated polysaccharides than the old Lycasin 80/55 (50% vs 21%, respectively [8]) and is less digestible but exerts low osmotic potential in the gut [9]. In addition, the insulinaemic index in normal subjects of Lycasin® HBC was lower than that of Maltisorb (33%) and that of Lycasin 80/55 (58%).

During the past 10 years many studies have identified the low glycaemic index diet as beneficial in the prevention and/or treatment of the metabolic syndrome [2, 3, 5, 10-12]. Several short and long term dietary interventions are available for healthy subjects and subjects with diabetes or hyperlipidemia. With few exceptions, these studies have shown that a low glycaemic index diet improves plasma glucose control, lipid profiles and insulin resistance. Thus, low

Fig 1. Plasma glucose (A) and insulin (B) responses to a 50 g oral glucose or Lycasin HBC® challenge in 6 non diabetic healthy subjects after an overnight fast. * p < 0.05 glucose vs Lycasin HBC® at each given time.
Glycaemic index carbohydrates appear to play an important role in the metabolic fate of carbohydrates. Consequently, such a diet might affect the risk of cardiovascular diseases, diabetes and obesity.

From the above data, it seems relevant to promote consumption of low glycaemic index sugars. This has been done recently by the joint Food and Agriculture Organisation (FAO) and World Health Organisation (WHO) Expert [13]. The last European dietary recommendation [14] for patients with type 2 diabetes suggest that most of the dietary energy intake should come from a combination of carbohydrates with low glycaemic index and mono-unsaturated fatty acids. In this optic the new Lycasin®HBC appears to be a very good candidate as a sugar replacer in candies for diabetic and non-diabetic subjects.

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Fig 2. Plasma glucose (A) and insulin (B) responses to a 50 g oral glucose or Lycasin HBC® challenge in 6 type 2 diabetic subjects after an overnight fast. * p < 0.05 glucose vs Lycasin HBC® at each given time.
REFERENCES


