The Science of Diabetic Snack Bars: A Review

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In recent years, diabetes health professionals and their patients have witnessed the growth of a new category of foods: diabetic snack bars. Today, there are various snack bars on the market, some that are specifically formulated to prevent hypoglycemia and others that are designed to lessen hyperglycemia. Table 1 offers a description of these products.

The diabetic snack bar category actually represents a heterogeneous variety of products with different ingredients, formulations, and intended usages. These differences are not always readily apparent to health professionals or patients. Diabetic snack bars are intended to provide convenient snack alternatives and partial meal replacements to be eaten within the context of the individualized meal plan. However, potential for misusing these products exists due to lack of understanding about the different ingredients and glycemic responses that can be expected from eating different types of snack products.

In order to make recommendations to their patients, clinicians should be aware of the evidence-based research that has been done in support of specific product claims. This article provides an overview of the specific products and their differing formulations and intended uses. It also reviews research studies that have demonstrated efficacy for the use of specific products.

The Use of Uncooked Cornstarch in Antihypoglycemia Bars

As shown in Table 1, there are three products on the market that contain uncooked cornstarch (UCS) designed to prevent hypoglycemia: Extend Bar (Clinical Products), Nite Bite (ICN Pharmaceuticals), and Gluc-O-Bar (APIC USA).

Background and Rationale for Using UCS

The genesis of the use of UCS came from studies in the area of glycogen storage disease that were pioneered originally by Chen et al.[1] in 1984 and further investigated by Wolfsforf and colleagues[2–4] during the 1990s. Type 1 glycogen-storage disease (GSD-1) is an inherited disorder in which there is absence or deficiency of glucose-6-phosphatase activity in the liver, kidney, and intestine. This leads to an accumulation of glycogen in these organs and rapid onset of hypoglycemia during fasting due to the inadequate release of glucose through normal glycogenolysis and gluconeogenesis. The goal of treatment of GSD-1 is to prevent hypoglycemia and to maintain blood glucose concentrations at a threshold above the level that would activate counterregulatory mechanisms that could induce deleterious secondary metabolic effects.

Affected children with GSD-1 are dependent on a constant source of dietary glucose to help maintain physiological postprandial and fasting blood glucose concentrations. UCS was tested in an attempt to identify a slowly absorbed complex carbohydrate that could be given as an oral therapy for providing exogenous glucose during the day and night.

IN BRIEF

Diabetic snack bars are formulated to either prevent hypoglycemia or reduce postprandial hyperglycemia. This article reviews this new product category and the evidence-based claims associated with specific products. Diabetes health care providers and their patients should be aware of how products differ based on ingredient formulations and intended uses.

The proven efficacy of orally administered UCS in GSD-1 paved the way for future studies in the diabetes arena. In a pilot study reported in 1992, Ververs et al.,[5] evaluated the use of UCS for prevention of nocturnal hypoglycemia in children with type 1 diabetes. UCS was given as the only source of complex carbohydrates to nine children (ages 9–18 years) and compared to a standard bedtime snack. Results of overnight blood glucose testing demonstrated that substituting the usual bedtime snack with UCS did not prevent hypoglycemia, but blood glucose levels dropped more slowly than those after the standard snack.

Individuals with type 1 diabetes suffer mild forms of hypoglycemia due to physiological imbalances that can occur as a result of variations in subcutaneous insulin absorption, food intake, and physical activity. With the results of the Diabetes Control and Complications Trial,[6,7] it became evident that intensive insulin therapy could help to minimize complications of type 1 diabetes, but that an increase in hypoglycemia, particularly nocturnal episodes, was a concomitant risk that would need to be addressed. Similar findings were described in the United Kingdom Prospective Diabetes Study regarding the increased incidence of hypoglycemia related to intensive therapy.[8]

Hypoglycemia in children with type 1 diabetes has long been a concern

Table 1. Comparison of Diabetic Snack Bars*††

Bars to Prevent Hypoglycemia

	Extend Bar (Clinical Products, Ltd.)**	**Nite Bite** Timed-Release Glucose Bar (ICN Pharmaceuticals, Inc.)**	**Gluc-O-Bar** (APIC, USA, Inc.)**
Claims on product package	Clinically proven to reduce episodes of low blood glucose for up to 9 h without causing high blood glucose	Helps prevent nighttime hypoglycemia; only glucose bar proven to be beneficial before exercise	Nutritional bar that provides sustained glucose release over a prolonged interval without sudden peaks
Description/use from product package	For use before bedtime, exercise, or whenever low blood glucose is likely to occur	Ideal before bed or exercise to help maintain blood glucose levels	Designed for use day or night as part of the dietary management of abnormal blood glucose levels
kcal	160	100	130
Carbohydrate (g)	30	15	21
UCS (g)	5	5	5
Fiber (g)	0	0	0
Sugars (g)	10 (fructose)	10 (sucrose)	1
Sugar alcohol (g)	5	0	11
Protien (g)	2.5	3	7
Fat (g)	2.5	3.5	2.5
Exchanges†	2 starch	1 starch, 0.5 fat	1.5 starch

Bars to Lessen Hyperglycemia

	Ensure Glucerna (Ross Products Division)	**Choice DM** (Mead Johnson Nutritionals)**	**Choice DM** Crispy Bars* (Mead Johnson Nutritionals)**
Claims on product package	Clinically shown to lower blood glucose response compared to an ordinary snack bar	Clinically shown to cause less rise in blood glucose levels compared to snack bars tested	Designed to minimize postprandial peaks in blood glucose levels
Description/use from product package	Complete, balanced nutrition specifically designed for people with diabetes. For use as a snack or occasional meal replacement	Nutritionally complete bars designed to help maintain blood glucose control; ideal as a snack between meals, after exercise, before bedtime, or anytime	"Pick-me-up" snacks for people with diabetes designed to help manage blood glucose levels
kcal	140	140	120
Carbohydrate (g)	24	19	21
Resistant starches (g)	4.8	3.2	1
Fiber (g)	4	3	1
Sugars (g)	7	9	5
Sugar alcohol (g)	5	6	7
Protein (g)	6	6	4
Fat (g)	4	4.5	2.5
Exchanges†	1.5 starch, 0.5 fat	1 starch, 1 fat	1.5 starch

*Nutrient data may vary slightly based on flavor.
**Peanut butter flavor used for comparison between brands; other flavors available.
†Exchange values as provided on product label.
††All bars contain between 60 and 110 mg Na and 50 and 105 mg K per serving.

because of its potential impact on brain development.[9–11] Young children and those with HbA_{1c} <8.0% have a higher risk of severe and moderate episodes of hypoglycemia.[12] Hypoglycemia frequently occurs without an obvious reason.[13–19] Daneman et al.[17] surveyed more than 300 children with type 1 diabetes and found that nearly 40% out of a total of 285 episodes of moderate and severe hypoglycemia occurred during sleep. The constant challenge of maintaining euglycemia without intermittent episodes of hypoglycemia might be eased with slowly released carbohydrate that provides a sustained source of glucose.

Why UCS Works

Cooked cornstarch will produce a higher blood glucose response than raw, or uncooked, cornstarch.[20,21] UCS is a complex carbohydrate composed of approximately 27% of the linear-chain dextrose polymer amylose and 73% of the branched-chain dextrose polymer amylopectin. Amylose has a compact structure and tight hydrogen bonding of the glucose chains, which makes it physically less susceptible to attack by amylolytic enzymes than the more open and branched amylopectin.[22] UCS is slowly hydrolyzed by amylase and is slowly absorbed from the gastrointestinal tract, providing a continuous source of glucose for entry into the systemic circulation for up to 6–7 h.[22] However, in its unheated form it is not very palatable, and efficacy alone may not be sufficient motivation for patients with diabetes, who may choose other snacks to avoid symptoms of hypoglycemia.

Studies of UCS

UCS has an even slower rate of digestion when eaten alone. However, when eaten in combination with other macronutrients (carbohydrates, protein, and fat) the rate of digestion of the other macronutrients is slowed as well, which may explain why it helps to provide a sustained release of glucose when eaten as part of a bedtime snack. An interesting study by Detlofsen et al.[23] was undertaken in Sweden to evaluate the effect of cornstarch on nocturnal blood glucose concentrations in very young children between the ages of 2 and 6 years. In this randomized, double-blind, placebo-controlled trial, 14 diabetic preschool children were given either 0.3 g/kg cornstarch or placebo solution as a supplement to the ordinary bedtime snack. Conditions of insulin dose, physical activity, and food intake were kept constant during the study period. The solution was given to the children if the blood glucose concentration at bedtime was between 5 and 12 mmol/l (90–216 mg/dl). Out of 140 study nights, one (1.4%) child experienced a blood glucose <3 mmol/l (54 mg/dl) compared to five (7.1%) episodes on placebo. This was not statistically significant ($P = 0.099$). However, the occurrence of hypoglycemic blood glucose concentrations below 5 mmol/l (90 mg/dl) was reduced by 64%.

Three randomized studies by Kaufman et al.[22,24,25] demonstrated that a bedtime snack containing UCS reduced the incidence of nocturnal hypoglycemia in intensive diabetes management.

In the first study,[24] 13 patients with type 1 diabetes, 3.0–17.5 years of age, with a history of nighttime hypoglycemia were selected. Patients followed a prescribed intensive diabetes regimen of either two or three insulin injections per day or continuous subcutaneous insulin infusion, adhered to a standard meal plan, and self-monitored blood glucose levels at least five times daily. The usual bedtime snack was given for 14 days (standard snack period), followed by 14 days in which 25–50% of the carbohydrate content was given as UCS in milk (test snack period). The dosage of cornstarch was determined by age so that subjects 12 years and older used 25% of the snack carbohydrate component as cornstarch.

Blood glucose levels were obtained at 0200 and before breakfast during the 28-day study. The mean number of hypoglycemic episodes at blood glucose <60 mg/dl or <3.3mmol/l at 0200 was significantly less for the test snack period (0.61 ± 0.87) than for the standard snack period (2.0 ± 2.12) ($P < 0.025$). There were also fewer hypoglycemic episodes before breakfast for the test snack period (0.69 ± 1.03) than for the standard snack period (2.61 ± 2.25) ($P < 0.010$). Potential side effects of cornstarch ingestion, including transient diarrhea, abdominal distention, and increased flatulence, were not reported, presumably because of the lower dosage that was used compared to what is ingested in patients with glycogen storage disease.

In another study, Kaufman and associates[22] included 5 g UCS in 2.5 oz of sugar-free pudding (total 17 g carbohydrate) plus one meat exchange and compared it to a standard snack of pudding alone equal to 17 g carbohydrate plus one meat exchange. Fifty-one type 1 diabetic subjects between 14 and 22 years of age were randomly given five nights of the cornstarch snack and five nights of the standard snack. Blood glucose values were obtained at midnight and at 0700. (See Fig. 1.)

The average incidence of hypoglycemia at midnight was 2.2% with cornstarch vs. 12.2% for the standard snack. At 0700, the average incidence of hypoglycemia was 4.5% with cornstarch versus 9.5% with the standard snack ($P < 0.001$ and $P < 0.05$, respectively). There was no difference in the number of hyperglycemic episodes between the two groups.

A third randomized, double-blind trial, also conducted by Kaufman and associates[25] evaluated the effect of a snack bar containing UCS equivalent to 1.5 starch exchanges (bar 1), compared to a control bar (bar 2), on the incidence of nocturnal and morning hypoglycemia. An important objective of this study was to formulate a snack bar with UCS that would be palatable.

Snack bar 1 and snack bar 2 differed in that only snack bar 1 contained

5 g of UCS; the bars were otherwise similar and were composed of soy protein isolate, peanut butter, water, polydextrose, peanuts, whey protein concentrate, natural flavors, sorbitol, and lecithin and citric acid. Both bars were 120 calories and equal to 23% protein, 54% carbohydrate, and 23% fat.

The subjects included 79 adolescents and adults (age 14–30 years). Subjects were randomly assigned to group A (five nights of snack bar 1 as the evening snack, followed by five nights of snack bar 2) or group B (five nights of snack bar 2 as evening snack, followed by five nights of snack bar 1). Snack bars were eaten with 4 oz of milk if the blood glucose level was ≥120 mg/dl. Additional starch, fruit, and meat exchanges were added based on an algorithm for bedtime blood glucose. Midnight and morning fingerstick blood glucose levels were compared to determine the incidence of hypoglycemia, defined as <60 mg/dl, as well as levels of hyperglycemia, which were defined as >250 mg/dl. HbA_{1c} was also measured to determine the effect of each bar on glycemia and to see whether there was individual variance based on the degree of established diabetes control.

There was a significant difference in the decrease in hypoglycemic events at midnight between snack bar 1 and snack bar 2 for the total cohort (3.3% using snack bar 1 [with cornstarch] vs. 15.3% using snack bar 2 [without cornstarch], $P < 0.001$). A similar result occurred in the morning for the total cohort (2.0% using snack bar 1 vs. 7.7% using snack bar 2, $P = 0.001$).

Both of the previous studies by Kaufman and colleagues were conducted in the setting of a diabetes camp at which campers and counselors were generally active. Therefore, the results of these studies probably also apply to a normal lifestyle, in which the activity level of individuals with type 1 diabetes may be more limited.

There was a significant decrease in the number of subjects who experienced hypoglycemia, as well as a significantly lower incidence of hyperglycemia at midnight, when subjects used snack bar 1 compared to snack bar 2. In addition, no association was found between HbA_{1c} level and the incidence of hypoglycemia. These results suggest that UCS provides a slow release of carbohydrate when consumed in combination with other carbohydrates and small amounts of protein and fat and diminishes episodes of nighttime and morning hypoglycemia without causing hyperglycemia.

The introduction of the continuous glucose monitoring system (CGMS, MiniMed), often called the glucose sensor, has offered new insights into daytime and nighttime blood glucose patterns and episodes of undetected hypoglycemia in individuals with type 1 diabetes. Studies using this system have shown that readings from blood glucose self-monitoring alone underestimate the incidence and duration of hypoglycemia, especially overnight.[26,27] The glucose sensor measures interstitial glucose levels 40–400 mg/dl every 5 min.

In a glucose sensor evaluation of the Extend Bar, 15 patients, ages 8–16 years, ate one Extend Bar each one night and ate a regular snack on two additional nights while wearing the monitoring device. Time periods were divided into 3-h intervals, and the number of high and low blood glucose levels were compared for the nights with and without the Extend Bar snack. The incidence of hypoglycemia was 2.8% when individuals ate the Extend Bar compared to 22% when they ate their regular snack ($P < 0.05$).[28]

Swedish investigators Axelsen et al.[29] recently reported on the use of UCS in two cohorts of type 2 diabetic patients and a separate cohort of type 1 diabetic patients. The study tested two hypotheses: *1*) that bedtime ingestion of UCS results in a lower and delayed nocturnal blood glucose peak compared to a conventional snack and *2*) that a bedtime carbohydrate supplement given as UCS prevents nocturnal hypoglycemia without altering metabolic control in intensively treated type 1 diabetic subjects.

A comparison was done in two groups of type 2 diabetic subjects who were studied on separate occasions. The first group ($n = 10$) was given a conventional snack consisting of whole-meal bread with butter and meat (0.6 g carbohydrates and 83.7 kcal ([20 kJ]/kg body weight). The second group ($n = 14$) was given 0.55g/kg UCS dissolved in low-sugar fruit juice (0.6 g carbohydrates and 41.84 kcal ([10 kJ]/kg body weight). On a separate day, these same subjects were also given a carbohydrate placebo of low-sugar fruit juice (0.1 g carbohydrates and 8.3 kcal ([2 kJ]/kg), which was masked with food coloring and thickening agents. Ingestion of the UCS snack blunted an increase in the blood glucose peak (2.9

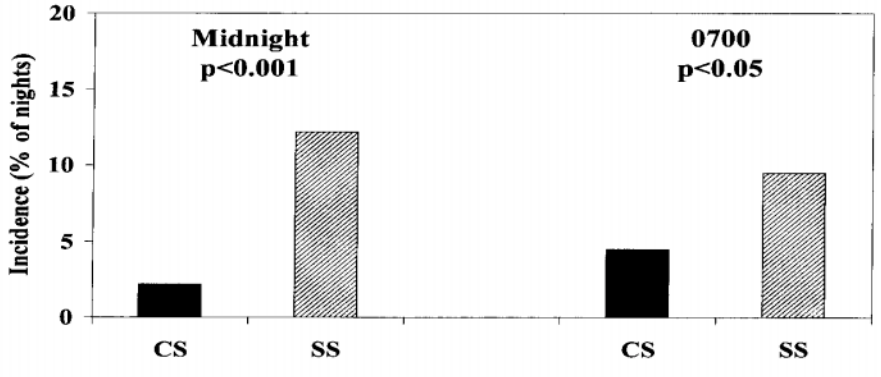

Figure 1. Incidence of hypoglycemic events in the cornstarch (CS) group compared to the standard snack (SS) group. Adapted from Kaufman et al.[22]

± 0.5 vs. 5.2 ± 0.6 mM, $P = 0.01$) and delayed the timing of this peak (4.3 ± 0.6 vs. 2.0 ± 0.0 h, $P = 0.01$) compared with a conventional snack.

In a 4-week, double-blind crossover study, 12 type 1 diabetic subjects ingested UCS (0.3 g/kg body weight) at 2300 h. Its effect was compared to that of a carbohydrate-free placebo. Subjects maintained all of their usual activity and insulin regimens and otherwise preserved their usual snacking patterns. The addition of this simple dietary maneuver diminished the number of self-estimated hypoglycemic episodes at 0300 h from 11 episodes during the placebo period to 3 episodes during the cornstarch period, a reduction of 70% ($P = 0.05$). There were no changes in HbA_{1c} or fasting lipids during the two supplement periods.

Two recent studies suggest an interesting possibility for the use of UCS to help reduce fasting hyperglycemia in type 2 diabetes. Axelsen and associates[30] compared the effect of two different doses of UCS given at bedtime in subjects with type 2 diabetes to determine the effects on morning glycemic control and HbA_{1c}. Diabetes therapy for all subjects was either diet alone or diet combined with oral medication. The effects of low-dose UCS (0.30 g/kg body weight; $n = 24$) and high-dose UCS (0.55 g /kg body weight; $n = 14$) were compared to a placebo without UCS. The high-dose bedtime supplement (~45 g UCS) increased overnight glycemic concentration but improved glucose tolerance after breakfast the next morning ($P < 0.05$). The low-dose UCS (~25 g) was associated with significantly lower fasting blood glucose concentrations after 4 and 7 weeks ($P < 0.05$). There were no improvements in insulin sensitivity or HbA_{1c} after 7 weeks at either dosage.

Dyer-Parziale[31] demonstrated that a snack bar containing UCS (Extend Bar) given at bedtime lessened midnight and morning episodes of hyperglycemia. Twenty-eight patients with type 2 diabetes ingested the study bar. Thirteen of the subjects were treated with oral agents, eight with a combination of insulin and oral agents, and seven with insulin alone. The study bar contained 30 g of carbohydrate, including 5 g of UCS. It was given for three nights followed by a placebo bar for three nights.

Blood glucose levels were determined before subjects were given the bedtime snack, at midnight, and again before breakfast. Blood glucose measurement determined the incidence of hypoglycemia (<60 mg/dl), hyperglycemia (>250 mg/dl), and mean differences in blood glucose levels when ingesting the study bar versus a placebo bar.

There were no episodes of hypoglycemia or hyperglycemia. The mean blood glucose levels at bedtime were nearly identical (study bar 117.5 ± 45.6 mg/dl vs. placebo bar 117.3 ± 40.0 mg/dl; $P = 0.977$). However, during the nights when subjects ate the study bar, midnight and fasting values before breakfast (study bar midnight value 127.9 ± 31.0 mg/dl vs. placebo bar midnight value 148.2 ± 32.1 mg/dl; $P = 0.001$; study bar breakfast value 114.2 ± 15.8 mg/dl vs. placebo bar breakfast value 158.49 ± 30.3 mg/dl; $P = 0.0001$). These data suggest that the ingestion of UCS in a product such as the Extend Bar or some other food vehicle may help to lessen the degree of fasting hyperglycemia.

It is intriguing that UCS helped to improve fasting blood glucose levels in both of these type 2 diabetes studies. These results are not entirely explainable, but possible mechanisms may be improved pancreatic insulin release as a result of suppressed fatty acid production or decreased hepatic glucose output. Furthermore, it is possible that the use of a diabetic snack bar with even smaller quantities of UCS may be advantageous for improving fasting blood glucose levels in subjects with type 2 diabetes.

It should be noted that Axelson and colleagues based the amount of UCS on body weight, which was more than the 5 g used in the studies by Kaufman and associates. It is possible that smaller quantities of UCS used in combination with other food may be efficacious. The appropriate quantity necessary for people with diabetes is obviously much less than that required for the treatment of GSD-1. The precise quantity of UCS and the most effective macronutrients to ingest with it have yet to be determined and could be a fruitful area for future clinical research.

Diabetic Snack Bars Using UCS to Prevent Hypoglycemia

Evidence-based claims for diabetic snack bars should be examined before recommending a product containing cornstarch because not all brands have been clinically tested. Individuals should review the ingredients and evaluate their own glycemic response to these products as part of a meal or snack on both a daytime and nighttime basis to determine each product's impact on their glycemic levels. It is important to not assume that all snack bars with cornstarch will have a similar effect on glycemic levels. Individuals will need to evaluate each product in terms of preventing hypoglycemia and overall glycemic impact because these bars have equal amounts of UCS but vary in other ingredients and macronutrient content.

Extend Bar. This is the only diabetic snack bar containing cornstarch for which clinical trials have determined efficacy for prevention of hypoglycemia. Claims are based on clinical studies demonstrating that the product helps in the dietary management and avoidance of low blood glucose for up to 9 h.

Extend Bar was formulated with 5 g UCS for the prevention of nocturnal hypoglycemia. Based on its long-acting release of glucose as confirmed by clinical trials, this snack bar can be used to help avoid low blood glucose between meals if eaten as part of a meal and to prevent exercise-induced hypoglycemia, which can occur several hours after physical activity.

Extend Bar has 160 kcal, approximately (nutrients vary slightly based on flavor) 30 g carbohydrates (of which 5 g is UCS), 3 g protein, and 2.5 g fat. It is equivalent to 2 starch exchanges. The product is sweetened with 5 g of sugar alcohol (sorbitol) and 8 g of fructose, which helps to provide a lower glycemic response.

Nite Bite Timed-Release Glucose Bar. This product is formulated to provide a "triphasic" sustained release of glucose for ~6 h or longer. The product is recommended for use to prevent nocturnal hypoglycemia or as part of a meal to help prevent low blood glucose levels.

The formulation of this bar has not been tested in clinical trials to determine its efficacy for preventing nocturnal or daytime hypoglycemia. However, the rationale and theoretical basis for its unique nutrient composition is described in an article by Bell and Forse.[32]

One study was undertaken to test the efficacy of the Nite Bite bar in preventing hypoglycemia for a very short duration after exercise compared to eating a usual pre-exercise snack of peanut butter and crackers.[33] Subjects had similar rates of hypoglycemia during and 2 h after exercise in the two groups. However, total calorie consumption and incidence of hyperglycemia after exercise were significantly lower ($P = 0.05$) with the Nite Bite snack.

Nite Bite contains a combination of 10 g of sucrose, 3 g of protein, 3.5 g of fat, and 5 g of UCS. It has 100 kcal and is equivalent to 1 starch exchange and 0.5 fat exchange.

Gluc-O-Bar. Two studies testing the efficacy of this product in type 1 diabetes are currently in progress but were not available at the time of this writing. The product package claims that this bar is a "slow release glucose bar" that "provides sustained glucose release over a prolonged interval without sudden peaks." It contains 130 kcal, approximately (nutrients vary slightly based on flavor) 22 g of carbohydrate (of which 5 g are from UCS), 6 g protein, and 2 g fat. It is equivalent to 1.5 starch exchanges.

Diabetic Snack Bars Designed to Lessen Hyperglycemia

In contrast to diabetic snack bars with UCS, which are formulated to prevent hypoglycemia, there are other bars on the market that aim to enhance glycemic control by reducing hyperglycemia. (See Table 1.) These products have unique formulations including ingredients such as resistant starches and fiber, which help to blunt the postprandial glycemic response.

Starches that are resistant to digestion (known as "resistant starches" [RS]) occur naturally in food. It is possible to commercially produce RS from cornstarch by increasing the proportion of amylopectin, a branched-chain starch, to amylose by allowing the starch molecule first to gelatinize and then cool. This allows the starch to "retrograde" into a crystalline starch that is highly resistant to digestion. The resulting compact structure, because of hydrogen bonding of glucose chains in amylose, renders it physically less accessible to amylolytic attack than the more open and branched amylopectin. Food companies can increase the degree of retrogradation to increase the amount of RS present.

RS, generally called "maltodextrin" on food labels, is considered as part of the total carbohydrate, but because it is incompletely digested, it is also represented as part of the dietary fiber on the food label. In contrast to UCS, which is slowly but nearly completely digested in the small intestine, RS is incompletely absorbed.[20,21] Since RS cannot be completely digested, it has a lower caloric value and makes less of an impact on blood glucose levels.[34,35]

Snack bars with RS are generally intended for daytime use. They are designed to be eaten as a nutritious snack or part of a meal to help provide carbohydrates that will release glucose at rates that can help to stabilize blood glucose levels without causing hyperglycemia.

Choice DM (Mead Johnson Nutritionals). This bar is available in two distinct formulations. The original snack bar is a nutritionally complete snack that can be eaten as part of a meal or as a snack. It contains 3.2 g of RS to help blunt postprandial blood glucose levels. The original Choice DM is fortified with 24 vitamins and minerals and provides 140 kcal from 19 g of carbohydrate, 6 g of protein, and 4.5 g of fat. It is equivalent to 1 starch and 1 fat exchange.

Reader et al.[36] reported on a double-blind, randomized, three-way crossover study on the glycemic response of Choice DM with RS compared to two other bars without RS: Benefit (Health Management Resources) and Snickers (M&M/Mars). The study included 10 subjects, ages 43–74 years, with type 2 diabetes, HbA_{1c} <9.0%, and fasting blood glucose (FBG) levels <200 mg/dl. Subjects were diagnosed at least 5 months earlier and weighed 100–150% of ideal body weight. After an overnight fast, subjects consumed a portion of the study bar containing 50 g of carbohydrate.

Significant differences were detected in the area under the curve (AUC/5 h) for glucose in the Choice DM bar compared to the other bars ($P = 0.001$). The maximum blood glucose level for Choice DM was 173.5 mg/dl compared to Benefit (205.6 mg/dl) and Snickers (205.8 mg/dl); $P < 0.001$. At 300 min, all blood glucose levels were the same for all bars.

This study demonstrated that the use of RS in the Choice DM bar was helpful in decreasing the postprandial glycemic response in patients with type 2 diabetes.

As part of a new line extension, Mead Johnson has recently introduced Choice DM Crispy Bars, which are meant to be used as a daytime snack to help stabilize glycemic levels. Their formulation includes 1 g of RS. The bar is sweetened with various ingredi-

ents, including high fructose corn syrup, used in combination with fructose and sugar alcohols (sorbitol, maltitol, or isomalt) to give it an acceptable glycemic profile for individuals with diabetes.

Choice DM Crispy Bars were tested in 20 subjects with type 2 diabetes.[37] Each participant consumed one Choice DM Berry Almond Crispy Bar after an overnight fast. Blood glucose was then measured at 30, 60, 90, 120, and 240 min after ingestion of the bar. The mean baseline FBG level was 150.7 mg/dl (SD ±2.3). The maximum increase in blood glucose from baseline occurred at 60 min and was 52.8 mg/dl (SD ±2.2) with a mean maximum blood glucose at 203 mg/dl (AUC/4 h was 4070.5; SD ±289.7).

Unfortunately, results were not available at the time of this writing comparing Choice DM Crispy Bars to another snack bar. However, plans were underway to conduct additional studies. Choice DM Crispy Bars are not fortified and have a different texture and taste than the original Choice DM bar. Each Crispy Bar is ~110 (almond berry flavor) or 120 (peanut butter flavor) calories, and each is approximately 1.5 starch exchanges. The Crispy Bars contain 21 g of carbohydrate, 4 g of protein, and 1.5–2.5 g of fat.

Ensure Glucerna (Ross Products Division, Abbott Laboratories). This snack bar has been reformulated since it originally became available. The new bar contains less guar gum than the original, and RS and fructooligosaccharides (a naturally occurring carbohydrate that acts as a water-soluble fiber) have been added to help enhance a lower glycemic response. The current Glucerna bar has 4 g of fiber from a combination of RS, guar gum, soy fiber, and microcrystalline cellulose to help further blunt postprandial blood glucose levels.

A comparative study was done to demonstrate the blood glucose profile of reformulated Glucerna bars compared to a common breakfast bar product (Kellogg's Nutri-Grain Bar).[38] This randomized, single-blind, controlled, crossover study was conducted in 24 adults with type 2 diabetes (mean age 56 ± 2.2 years) and a mean body mass index of 29 ± 1.1 kg/m^2. Diabetes therapy for all subjects was diet only or diet and oral medication.

A 4-h meal glucose tolerance test was performed at each study visit, during which glucose responses were measured after subjects ingested two bar portions of either the control bar (Nutri-Grain) or reformulated Glucerna containing 4.77 g of RS. The area under the curve (AUC/4 h) from 0 to 240 min for glucose was significantly greater for the control bar (6,413 ± 930 mg/dl) than for the reformulated Glucerna bar (1,755 ± 651 mg/dl), $P < 0.001$. The adjusted glucose response to the control bar was also significantly higher than the glucose response to the study bar at 30, 45, 90, 120, and 180 min, $P < 0.001$.

The Glucerna bar is fortified with 24 vitamins and minerals and provides 140 kcal from 24 g of carbohydrate, 6 g of protein, and 4 g of fat. It is equivalent to 1.5 starch exchanges and 0.5 fat exchange.

These clinical studies demonstrate that the use of RS as part of the total carbohydrate content in diabetic snack bars helps to provide a lower glycemic response than regular snack bars with a similar calorie and macronutrient content.

Clinical Implications

- Patients on intensive insulin therapy regimens who are in very good control may benefit most from using diabetic snack bars that contain UCS because they are more susceptible to episodes of hypoglycemia during the day and at night.
- None of these products should be used as treatment for hypoglycemia because diabetic snacks are not formulated to act quickly enough to alleviate symptoms of hypoglycemia.
- In general, snack bars with UCS are meant to be used as part of a bedtime snack to prevent hypoglycemia at night. The other snack bars are meant to help prevent hyperglycemia during the day. Snacks meant for daytime use may not be suitable as nighttime snacks for prevention of nocturnal hypoglycemia, particularly when eaten alone.
- Products should not be viewed as being "interchangeable," even when the carbohydrate content is similar. Diabetic snack bars will have different glycemic effects depending on the use of various types of ingredients, such as UCS, RS, fiber, sugar alcohols, and other types of simple and complex carbohydrates.
- Control of postprandial blood glucose: Bars containing RS are designed to blunt postprandial blood glucose excursions. Some bars containing UCS may have a similar impact.
- Weight control: Diabetic snack bars can assist patients by offering a satisfying, convenient, portion-controlled food with limited calories. In addition, diabetic snack bars can also help to prevent weight gain by eliminating excess calories eaten to alleviate symptoms of hypoglycemia.
- Exercise: Diabetic snack bars are not useful for providing fast-acting glucose before exercise but are definitely advantageous for giving a slow, sustained release of glucose, which can prevent hypoglycemia immediately after exercise of moderate intensity as well as several hours later.
- Conventional snack bars with 15–30 g of simple and complex carbohydrates will be more effective in providing an immediate available source of glucose before exercise.
- Diabetic snack bars containing UCS may be recommended to avoid low blood glucose after ingestion of alcohol.
- Individuals who suffer from hypoglycemic unawareness may benefit from the use of snack bars with UCS to help prevent episodes of hypo-

glycemia throughout the day or night.

- Patients using insulin secretagogues are also at risk of hypoglycemia if sufficient carbohydrate is not eaten as part of a meal. Diabetic snack bars can provide the necessary carbohydrate to avoid low blood glucose levels after meals or in the event of a delayed meal. Snack bars with ingredients that provide a blunted postprandial response may be helpful in type 2 patients and can be substituted for a bedtime snack with a reduced hyperglycemic response.
- It is possible that diabetic snack bars may have a role in nutritional management of pregnancy. Snack bars with UCS or RS may help to avoid morning postprandial blood glucose elevations when eaten as part of breakfast, a time when carbohydrates often need to be restricted. Snack bars with UCS may also be helpful, since the slowly absorbed carbohydrate will help to prevent overnight hypoglycemia and the occurrence of morning urine ketones.
- Snack bars for diabetes are designed either to prevent hypoglycemia, particularly nocturnal episodes, or to blunt hyperglycemia. Both types are preferable to regular snack bars, including health bars, energy bars, or candy bars, which provide quickly absorbed carbohydrates. Ingestion of regular snack bars may result in exaggerated glycemic excursions and is not effective for prevention of hypoglycemia.

REFERENCES

[1]Chen Y-T, Cornblath M, Sidbury JB: Cornstarch therapy in type 1 glycogen-storage disease. *N Engl J Med* 310:1721–1725, 1984

[2]Wolfsdorf JI, Plotkin RA, Laffel LMG, Crigler JF: Continuous glucose for treatment of patients with type I glycogen-storage disease: comparison of the effects of dextrose and UCS on biochemical variables. *Am J Clin Nutr* 52:1043–1050, 1990

[3]Wolfsdorf JI, Ehrlich S, Landy HS, Crigler JF: Optimal daytime feeding regimen to prevent postprandial hypoglycemia in type I glycogen storage disease. *Am J Clin Nutr* 56:587–592, 1992

[4]Wolfsdorf JI, Crigler JF: Cornstarch regimens for nocturnal treatment of young adults with type 1 glycogen storage disease. *Am Soc Clin Nutr* 65:1507–1511, 1997

[5]Ververs MT, Rouwé C, Smit GP: Complex carbohydrates in the prevention of nocturnal hypoglycaemia in diabetic children. *Eur J Clin Nutr* 47:268–273, 1993

[6]The DCCT Research Group: The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. *N Engl J Med* 329:977–986, 1993

[7]The DCCT Research Group: Adverse events and their association with treatment regimens in the Diabetes Control and Complications Trial. *Diabetes Care* 18:1416–1427, 1995

[8]United Kingdom Prospective Diabetes Study Group: Intensive blood-glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes. *Lancet* 352:837–853, 1998

[9]Ryan C, Vega A, Drash A: Cognitive deficits in adolescents who developed diabetes early in life. *Pediatrics* 75:921–927, 1985

[10]Rovet JF, Ehrlich RM, Hoppe M: Intellectual deficits associated with early onset of insulin-dependent diabetes mellitus in children. *Diabetes Care* 10:510–515, 1987

[11]Bjorgaas M, Gimse R, Vik T, Sand T: Cognitive function in type 1 diabetic children with and without episodes of severe hypoglycemia. *Acta Paediatr* 86:148–154, 1997

[12]Davis EA, Keating B, Byrne GC, Russell M, Jones TW: Hypoglycemia: incidence and clinical predictors in a large population-based sample of children and adolescents with IDDM. *Diabetes Care* 20:22–25, 1997

[13]Whincup G, Milner RDG: Prediction and management of nocturnal hypoglycaemia in diabetes. *Arch Dis Child* 62:333–337, 1986

[14]Schiffrin A, Suissa S: Predicting nocturnal hypoglycemia in patients with type 1 diabetes treated with continuous subcutaneous insulin infusion. *Am J Med* 82:1127–1132, 1987

[15]Shalwitz RA, Farkas-Hirsch R, White NH, Santiago JV: Prevalence and consequences of nocturnal hypoglycemia among conventionally treated children with DM. *J Pediatr* 116:685–689, 1990

[16]Matyka KA, Crowne EC, Havel PJ, MacDonald, IA, Matthews D, Dunger D: Counterregulation during spontaneous nocturnal hypoglycemia in prepubertal children with type 1 diabetes. *Diabetes Care* 22:1144–1150, 1999

[17]Daneman D, Frank M, Perlman K, Tamm J, Ehrlich R: Severe hypoglycemia in children with insulin-dependent DM: frequency and predisposing factors. *J Pediatr* 115:681–685, 1989

[18]Macfarlane PI, Walters M, Stutchfield P, Smith CS: A prospective study of symptomatic hypoglycemia in childhood diabetes. *Diabet Med* 6:627–630, 1989

[19]Bergada I, Suissa S, Dufresne J, Schiffrin A: Severe hypoglycemia in IDDM children. *Diabetes Care* 12:239–244, 1989

[20]Jenkins, DJA, Wolever GMS, Jenkins AL: Fiber and other dietary factors affecting nutrient absorption and metabolism. In *Modern Nutrition in Health and Disease.* 9th edition. Baltimore, MD, Willliams & Wilkins, 1999, p. 679–697

[21]Wolf BW, Bauer LL, Fahey GC Jr: Effects of chemical modification on in vitro rate and extend of food starch digestion: an attempt to discover a slowly digested starch. *J Agric Food Chem* 47:4178–4183, 1999

[22]Kaufman FR, Halvorson M, Kaufman ND A randomized, blinded trial of UCS to diminish nocturnal hypoglycemia at diabetes camp. *Diab Res Clin Pract* 30:205–209, 1995

[23]Detlofson I, Kroon M, Aman J: Oral bedtime cornstarch supplementation reduces the risk for nocturnal hypoglycaemia in young children with type 1 diabetes. *Acta Paediatr* 88:595–597, 1999

[24]Kaufman FR, Devgan S: Use of UCS to avert nocturnal hypoglycemia in children and adolescents with type 1 diabetes. *J Diabetes Compl* 10:84–87, 1996

[25]Kaufman FR, Halvorson M, Kaufman ND: Evaluation of a snack bar containing UCS in subjects with diabetes. *Diabetes Res Clin Pract* 35:27–33, 1997

[26]Gross TM, Mastrototaro LP, Fredrickson LP: Detection of unseen hypoglycemia using continuous glucose monitoring (Abstract). *Diabetologia* 43 (Suppl. 1):19, 2000

[27]Boland EA, Delucia M, Brandt C, Grey M, Tamborlane WV: Limitations of conventional methods of self blood glucose monitoring: lessons learned from three days of continuous glucose monitoring (CGMS) in pediatric patients with type 1 diabetes (Abstract). *Diabetes* 49 (Suppl. 1):A397, 2000

[28]Personal communication with Fran R. Kaufman, MD, Oct. 17, 2000

[29]Axelsen M, Wesslau C, Lönnroth P, Arvidsson Lenner R, Smith U: Bedtime UCS supplement prevents nocturnal hypoglycemia in intensively treated type 1 diabetes subjects. *J Intern Med* 245: 229–236, 1999

[30]Axelsen M, Lönnroth P, Lenner RA, Taskinen MR, Smith U: Suppression of nocturnal fatty acid concentrations by bedtime carbohydrate supplement in type 2 diabetes: effects on insulin sensitivity, lipids, and glycemic control. *Am J Clin Nutr* 71:1109–1114, 2000

[31]Dyer-Parziale M: The effect of Extend Bar containing UCS on nighttime glycemic excursion. *Diabetes Res Clin Pract.* In press

[32]Bell SJ, Forse RA: Nutritional management of hypoglycemia. *Diabetes Educ* 25:41–47, 1999

[33]Bell SJ, Kistler J, Mullooly CA, Ovalle, KB, Zilvitis B, Forse RA: Glycemic control during exercise in type 1 diabetes: comparison of a new medical food bar with usual care. *Diabetes Care* 21:1775–1777, 1998

[34]Brown I: Complex carbohydrates and resistant starch. *Nutr Rev* 54:S115–S119, 1996

[35]Kevin K: Starch de resistance. *Food Processing* January 1995, p. 65–67

[36]Reader D, Johnson ML, Hollander P, Franz M: The glycemic and insulinemic response of resistant starch in a food bar vs. two commercially available food bars in persons with type II diabetes mellitus (Abstract). *Diabetes* 46 (Suppl. 1):254A, 1997

[37]Data on file at Mead Johnson Nutritionals. Provided November 3, 2000

[38]Data on file at Ross Products Division, Abbott Laboratories. Provided November 10, 2000

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Note of Disclosure: *Ms. Rafkin-Mervis has served as a consultant to Clinical Products, Ltd., makers of Extend Bar.*