# Frozen Desserts and Glycemic Response in Well-Controlled NIDDM Patients

Julie Bukar, RD
Nicholas H.E. Mezitis, MD
Vassiliki Saitas, MD
F. Xavier Pi-Sunyer, MD

**Fructose is known to elicit a lower glycemic response than sucrose, and high-fructose desserts have been recommended for a diabetic diet. We compared a cholesterol-free tofu-based frozen dessert (TFD) containing high-fructose corn syrups with a dairy-based sucrose-sweetened ice cream (IC). Six male and six female non-insulin-dependent diabetic patients (mean age 51 yr, mean ideal body weight 143%, fasting blood glucose <160 mg/dl) with well-controlled diabetes and managed on oral hypoglycemic agents were studied. Subjects underwent three trials. In the first trial they ingested 50 g glucose, and in the next two trials they ingested 50-g carbohydrate equivalents of either TFD or IC in random sequence. Venous blood was drawn at intervals during the 3-h trials for glucose and insulin determinations. Fasting plasma glucose was not statistically different between IC and TFD trials (130 vs. 121 mg/dl). Peak glucose responses were at 120 min in both trials (190 mg/dl for IC and 222 mg/dl for TFD), with those for TFD being significantly higher ($P < 0.01$). Mean glucose area and glycemic index for TFD were significantly greater than for IC ($P < 0.01$ and $P < 0.03$, respectively). There was no significant difference between mean insulin areas. In summary, the TFD, which contains soybean curd and high-fructose corn syrup, might have been expected to produce more satisfactory postprandial blood glucose levels than IC, which contains sucrose, yet a higher glycemic response was elicited. This is related to the substantial amount of total glucose in this "fructose" dessert. The study highlights the error of using individual components of a commercially prepared food to recommend a product for diabetic patients. *Diabetes Care* 13:382–85, 1990**

From the Division of Endocrinology, Diabetes, and Nutrition, St. Luke's/Roosevelt Hospital Center, Columbia University College of Physicians and Surgeons, New York, New York.

Address correspondence and reprint requests to Julie Bukar, RD, Clinical Research Associate, Genentech, Inc., #59, 460 Pt. San Bruno Boulevard, South San Francisco, CA 94080.

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Dietary compliance plays a key role in maintaining euglycemia in diabetes mellitus. Indeed, non-insulin-dependent diabetic (NIDDM) patients are often treated by diet alone. Complying with any diet is difficult and is much more so with one that limits sweets, including ice cream. This has led to a growing interest in dietetic foods and nutritive sweetener alternatives to sucrose for diabetic patients.

Fructose has a lower glycemic index (20 ± 5%) than glucose (100%) and sucrose (59 ± 10%) (1). When each of these carbohydrates is given alone or with a test meal, fructose produces a lower glycemic and insulin response than sucrose or glucose (2,3). Both fructose-sweetened cake and ice cream elicit a less-pronounced glycemic response compared with sucrose-sweetened cake and ice cream (4).

Fructose is also sweeter than sucrose, particularly at low temperatures such as those of ice cream (5). Therefore, a palatable fructose-containing dessert may contain fewer calories, which is important for diabetic patients requiring weight reduction.

High-carbohydrate high-fiber diets have been beneficial in lowering postprandial glucose levels in diabetic patients (6). Lipid profiles are also improved (6). The viscous or soluble fibers, of which legumes have a great deal (7), have a more pronounced effect in this regard. Soybeans have one of the lowest glycemic indices of all foods tested (15 ± 5), including milk (1). Tofu is made from soybean curd.

**TABLE 1**
**Macronutrient composition of test desserts**

| | Glucose load | | Tofu frozen dessert | | Ice cream | |
|---|---|---|---|---|---|---|
| | g | %* | g | %* | g | %* |
| Carbohydrate | 50 | 52 | 51 | 17 | 50 | 14 |
| Protein | | | 9 | 3 | 7 | 2 |
| Fat | | | 24 | 8 | 21 | 6 |

Values are calculated from manufacturers' information.
*Percentage by weight; the rest is water.

Thus, a high-fructose tofu-containing frozen dessert (TFD) might be preferable for diabetic patients compared with a dairy-based sucrose-containing ice cream (IC) because of the predicted lower glycemic effect of its ingredients. Data that would permit making any recommendations relative to these desserts are scarce, prompting us to undertake this study.

## RESEARCH DESIGN AND METHODS

Six male and six female NIDDM subjects (mean age 51 ± 11 yr, mean ideal body weight 143 ± 44%) volunteered for the study. All were being managed on oral hypoglycemic agents (3 on glyburide, 7 on chlorpropamide, and 2 on tolbutamide).

**Experimental design.** Subjects initially underwent an induction period until their finger-stick fasting blood glucose was <160 mg/dl for at least 5 consecutive days. The induction period consisted of nutrition counseling to improve diabetes control. If nutrition counseling alone was not effective, the dose of oral hypoglycemic agent was increased until the desired level of glycemia was achieved. The study consisted of three trials conducted at 0900, at least 2 days apart. Subjects fasted overnight and took all their usual medications, including oral hypoglycemic agents, before each trial.

**TABLE 2**
**Carbohydrate composition of test desserts**

| | Glucose load | | Tofu frozen dessert | | Ice cream | |
|---|---|---|---|---|---|---|
| | g | %* | g | %† | g | %† |
| Fructose | | | 12.2 | 24 | | |
| Sucrose | | | | | 33.5 | 67.0 |
| Glucose | 50 | 100 | 14.8 | 29 | 1.5 | 3.0 |
| Maltodextrins | | | 23.0 | 46 | 3.0 | 6.0 |
| Lactose | | | | | 11.5 | 23.0 |

*Manufacturers' information.
†Percentage by weight of total carbohydrate by analysis.

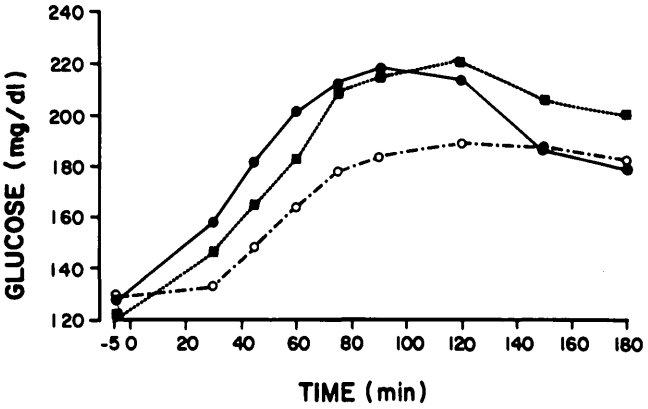


**FIG. 1. Mean plasma glucose concentrations before and after glucose load (●) and desserts. ○, Ice cream; ■, tofu frozen dessert.**

The first trial consisted of a 50-g glucose load. For the second and third trials, subjects consumed a chocolate TFD or IC given in random sequence. Products were chosen based on their relatively equal macronutrient content and their ingredients. Both products were available on the consumer market at the time of the study.

Fasting venous blood samples were taken 5 min before eating. Eating began at time 0. Subjects were given 15 min to consume the test food. Venous blood was drawn for glucose and insulin determinations at 30, 45, 60, 75, 90, 120, 150, and 180 min.

**Analyses.** Plasma samples were analyzed for glucose by a glucose oxidase method with the Beckman glucose analyzer (Fullerton, CA). Plasma insulin was measured by radioimmunoassay (8). Areas under the glucose and insulin curves were calculated geometrically. The mean glycemic index was expressed as a percentage and was calculated by taking the glucose area of the test food curve and dividing it by the area under the glucose-load curve. Statistical significance of the results was calculated with Student's *t* test for dependent means.

The macronutrient content of the test foods was based on the manufacturers' information (Table 1). The percentages by weight of individual sugars in the carbohydrate portion of the desserts were determined by B. Lewis (Dept. of Nutritional Sciences, Cornell University, Ithaca, NY) and are given in Table 2. These were determined by high-performance liquid chromatography (9), gas-liquid chromatography (10), and acid-extraction techniques (11).

## RESULTS

The fasting mean plasma glucose levels before the three trials, i.e., glucose, IC, and TFD, were not significantly different (128, 130, and 121 mg/dl, respectively; Fig. 1). Peak mean glucose responses occurred 120 min postprandially for the TFD and IC trials (222 and 190

**TABLE 3**
**Mean ± SE areas under curves**

| | Glucose load | Ice cream | Tofu frozen dessert |
|---|---|---|---|
| Mean glucose area (mg · min$^{-1}$ · dl$^{-}$) | 11,090 ± 1873 | 7194 ± 1581 | 12,302 ± 2287* |
| Mean insulin area (μU · min$^{-1}$ · dl$^{-}$) | 4155 ± 1180 | 7574 ± 1510 | 7548 ± 1655 |
| Glycemic index (%) | 100 ± 0 | 68 ± 15 | 115 ± 14* |

*$P < 0.05$ vs. ice cream group.

mg/dl, respectively), with the TFD response being significantly higher ($P < 0.01$). The mean postprandial glucose area was significantly higher for TFD than IC (Table 3).

Fasting mean insulin levels for the glucose, TFD, and IC trials were not significantly different at 47, 40, and 43 μU/ml, respectively (Fig. 2). Peak mean insulin response after the glucose load occurred at 90 min and was 78 μU/ml. Peak mean insulin levels occurred at 120 min for both TFD and IC (104 and 107 μU/ml, respectively) and were not significantly different. Mean insulin areas for TFD or IC were not significantly different (Table 3). The glycemic index for TFD (115 ± 14%) was significantly higher than for IC (68 ± 15%; $P = 0.03$) (Table 3).

## DISCUSSION

The TFD, which contains soybean curd (tofu) and fructose, might have been expected to produce lower blood glucose levels in diabetic patients than IC, which contains sucrose. In fact, the TFD produced a significantly higher glycemic response than IC. The higher glycemic response with TFD is probably related to the substantial amounts of maltodextrin and glucose in this fructose-containing product (Table 2).

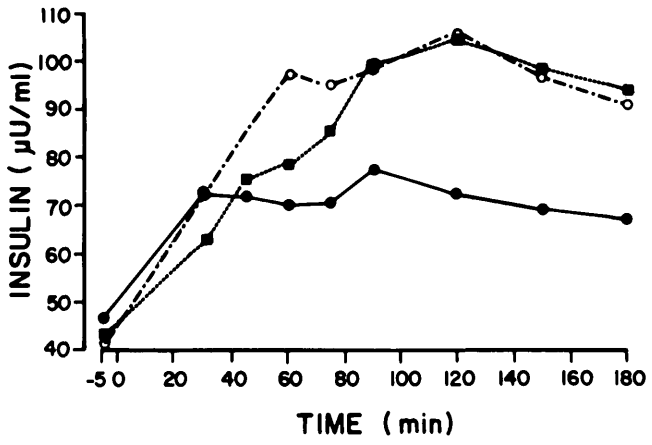


**FIG. 2. Mean plasma insulin concentrations before and after glucose load (●) and desserts. ○, Ice cream; ■, tofu frozen dessert.**

TFD contains 24% of its carbohydrate as fructose, 29% as glucose, and 46% as maltodextrins. Because maltodextrins are chains of glucose molecules, the carbohydrate content of TFD after gut hydrolysis would be 24% fructose and 75% glucose (Table 4).

The carbohydrate in IC was 67% sucrose (glucose + fructose), 23% lactose (glucose + galactose), 6% maltodextrin (glucose), and 3% free glucose, thus containing 54% glucose, 11.5% galactose, and 33.5% fructose after gut hydrolysis. Therefore, the IC contained more fructose than the TFD (33.5 vs. 24%) and less glucose (54 vs. 75%). In addition, because the hydrolysis of lactose is the slowest of all the carbohydrate digestive-absorptive processes (12), the glucose (and galactose) absorption from the 11.5 g of lactose in the IC would be relatively delayed.

Finally, the TFD contained 46% of its glucose as maltodextrins. Maltodextrins are the remains of incomplete starch hydrolysis and contain glucose units of various chain lengths both with and without α-1,6 branch linkages. It has been reported that oligosaccharides that are composed of 3–10 glucose units and contain no α-1,6 linkages are absorbed faster than free glucose (13). Some of the glucose obtained from the maltodextrins may have been absorbed more rapidly than either free glucose or glucose obtained from sucrose or lactose hydrolysis.

High-fructose corn syrup was the only carbohydrate source listed on the TFD product label. The TFD, which

**TABLE 4**
**Carbohydrate content of study desserts**

| Percentage of carbohydrates in dessert* | Percentage of individual monosaccharides | | |
|---|---|---|---|
| | Glucose | Fructose | Galactose |
| Ice cream | | | |
| 67% sucrose | 33.5 | 33.5 | 0 |
| 23% lactose | 11.5 | 0 | 11.5 |
| 6% maltodextrin | 6.0 | 0 | 0 |
| 3.0% glucose | 3.0 | 0 | 0 |
| Total | 54.0 | 33.5 | 11.5 |
| Tofu frozen dessert | | | |
| 24% fructose | 0 | 24 | 0 |
| 29% glucose | 29 | 0 | 0 |
| 46% maltodextrin | 46 | 0 | 0 |
| Total | 75 | 24 | 0 |

*Percentages do not add up to exactly 100% because each saccharide was measured individually.

contained between 42 and 55% high-fructose corn syrup according to the manufacturer's information, was found on analysis to have only 24% of its carbohydrate as fructose, suggesting that proprietary information may be unreliable.

The soluble fiber content in soybeans and other legumes is thought to lower blood glucose response by retarding glucose absorption (14). When soybeans are cooked, pureed, and pressed through a cloth to make tofu, the fiber content virtually disappears (<2% of total weight; 15). Therefore, the proposed "lente" effect may also be expected to disappear.

Americans are known to consume more ice cream per capita than the people of any other country, making it likely that even people with diabetes in this country will seek to include ice cream or an ice cream alternative in their diet (16). Our study highlights the problem of the consumer with diabetes who, on seeking a sweet frozen dessert, may mistakenly consider a product beneficial after examining its ingredient label. For example, the IC label lists milk fat and nonfat milk, sugar, etc., whereas the TFD ingredients listed are water, tofu, high-fructose corn syrup, corn oil, etc. The consumer, not knowing that high-fructose corn syrups contain large amounts of glucose, may choose the TFD based on the knowledge that legumes, fructose, and polyunsaturated fats are better food choices for individuals with diabetes than a high–animal-fat, sucrose-containing product. In this case, choosing the TFD over the IC would clearly not benefit diabetes control. TFD offers no advantage over IC as long as the saturated fat content of the total diet is reasonable.

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