RESPONSE OF BLOOD GLUCOSE LEVELS
TO VARIATIONS OF THE
MEAL-ON-THE-GO BAR

By

Julie K. Collins

Bachelor of Science in Home Economics

Oklahoma State University

Stillwater, Oklahoma

1986

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
July, 1988

RESPONSE OF BLOOD GLUCOSE LEVELS

TO VARIATIONS OF THE

MEAL-ON-THE-GO BAR

Thesis Approved:

Sue Knight
Thesis Advisor

Christa Hansen

P. L. Claypool

Norman N. Durham
Dean of the Graduate College

ACKNOWLEDGEMENTS

I would like to thank Dr. Sue Knight, my major advisor, who was very helpful and guided me through this research probject. I would also like to thank my committee members, Dr. Christa Hanson and Dr. Larry Claypool, who have put a lot of time and effort into this project. I want to thank the Provesta Corporation for funding my research project and for providing me with needed literature. I want to thank the Staley Company for providing me sugar samples. My greatest gratitude and love goes to my husband, Joe C. Collins, for being so patient and understanding of my educational pursuits. My parents also deserve thanks because they have supported me always.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Food technologists are responsible for developing food products which meet the needs of varying individuals. This includes people who have health problems where diet may be an important factor in controlling their health problems. It is important that the food technologists learn as much as possible about a specific health problem to best cater to the needs of those with that problem.

Diabetes is a widespread, prominent disease condition in the United States and accounts for a large number of deaths each year. The following statistics were taken from Diabetes Facts and Figures by the American Diabetes Association (1987):

(1) Diabetes is a leading cause of death by disease in the U.S. killing 300,000 people each year;

(2) Each year 5,000 people lose their sight because of diabetes;

(3) Diabetic eye disease is the number one cause of new blindness in people between the ages of 20 and 74;

(4) Ten percent of all people with diabetes develop kidney disease;

(5) Nearly 25 percent of all new dialysis patients are people with diabetes;

(6) About 45 percent (or more than 30,000) of all non-traumatic leg and foot amputations in the U.S. are caused by diabetes;

(7) People with diabetes are 2 to 4 times more likely to have heart disease;

(8) People with diabetes are 2 to 6 times more likely to have a stroke;

(9) Diabetes can lessen the chance of a successful pregnancy and increases the risk of birth defects;

(10) Direct and indirect costs for diabetes run $14 billion annually and account for 3.6 percent of total U.S. health costs.

To control the disease, several factors must be balanced, including exercise and medication. Diet is also very important because it prevents rapid excursions in blood sugar levels. Medications such as insulin therapy and sulfonurea drugs control diabetes and exercise helps to lower blood sugar levels but these are not cures for this disease. Therefore, development of foods that aid diabetics in managing their disease is very beneficial.

Purpose and Objectives

The purpose of this research was to determine the blood glucose response of the recently developed Meal-on-the-Go Bar and compare the response to that of a similar bar totally sweetened with fructose. However, the fat and protein in these bars may modify the responses. Therefore, the responses and glycemic indices of the bars should also be compared with a bar that has an equal amount of protein, fat, and carbohydrate.

The objectives for this study were as follows:

1. To Determine the glycemic response of subjects to 50 grams of carbohydrate as:

A. Meal-on-the-Go Bar

B. Iso-Bar

C. Fructose Bar

D. Compare these to that of 50g of glucose in the glucose tolerance test.

The following hypothesis was tested in this study:

HO: There are no differences among glycemic responses of subjects due to 50 grams of carbohydrate as:

A. Meal-on-the-Go Bar

B. Iso-Bar

C. Fructose Bar

D. Liquid Glucose

Assumptions and Limitations

The following assumptions were made about this study:

1. The subjects will be able to eat all the test meals in the given amount of time.

2. The glucose tolerance test given will indicate subjects who do not have normal blood glucose values.

3. The timing of blood glucose tests will indicate all peaks and declines from the test meals.

The following limitations are presented in this study:

1. Diabetic or hypoglycemic subjects will not be used in this research due to limited resources and ethical considerations.

2. Time and resources are limited.

Definitions

The definitions explaining terms used in this study are as follows:

Diabetes: "An impaired ability to metabolize carbohydrates, an increased concentration of glucose in the circulating blood, and the excretion of varying amounts of glucose in the urine" (Krause, Mahan, 1984).

Complex carbohydrates: "Carbohydrates other than mono- and diglycerides" (Dorland, 1985).

Dietary fiber: "Indigestible plant cell wall constituents. A heterogenous group of substances whose metabolic effects may differ according to degree of water solubility" (Parsons, 1984).

Glucose tolerance test (GTT): "A given amount of glucose is given after 12 hours of fasting and blood samples are drawn frequently to determine if blood glucose values are in a certain range (70-120mg/dl)" (Stevens, 1978).

Glycemic index: "Compares the response of different forms of foods to that of equal amounts of glucose" (Jenkins, 1984).

<u>Glycemic response</u>: "The insulin response to glucose in the blood" (Krause, 1985).

<u>Hyperglycemia</u>: "An excess of glucose in the blood" (Dorland, 1985).

<u>Hypoglycemia</u>: "A deficiency of glucose concentration in the blood" (Dorland, 1985).

<u>Neuropathy</u>: "Functional disturbances of the central nervous system" (Dorland, 1985).

<u>Nephropathy</u>: "Disease of the kidneys" (Dorland, 1985).

<u>Postprandial</u>: "After a meal" (Dorland, 1985).

<u>Retinopathy</u>: "Noninflamatory disease of the retina" (Dorland, 1985).

<u>Tonicity</u>: "The effective osmotic pressure equivalent" (Dorland, 1985).

<u>Lente carbohydrates</u>: "Foods that are rich in viscous unabsorbable plant gums, pectins and storage polysaccharides such as guar and tragacanth, and natural enzyme inhibitors" (Krause, 1984).

CHAPTER II

REVIEW OF LITERATURE

Having good control over blood glucose levels is important for individuals with diabetes. This control can be brought about by diet modification and insulin therapy. Certain recently developed foods may conform to these diet modifications. This includes foods that are high in carbohydrates and dietary fiber and low in overall fat. Foods which contain simple sugars may also be considered in diabetic diets.

Diet Recommendations

Diet is a main component of good control. The goals of the diet should be to maintain blood glucose levels as close to normal as possible and prevent rapid rises in blood sugar levels. Proper diets should allow the diabetic to maintain an ideal weight and insulin sensitivity. It should be moderate in fat to prevent the development of atherosclerosis. For good compliance, the diet must be palatable and contain a wide variety of foods (Krause, 1985).

A person with diabetes must balance three nutrients in the diet: protein, fat, and carbohydrate. Protein calories should be 15 to 20 percent of the diet to maintain body tissues and enzyme levels. The protein needs to be complete, containing all the essential amino acids. Fat intake should not exceed 30-35 percent of the daily calories. The fat sources should be mostly polyunsaturated with saturated fats limited. The amount of carbohydrate recommended for diabetics is 55-60 percent of total calories (Krause, 1985). This high complex carbohydrate content is important for preventing a high triglyceride level in the blood. The carbohydrate should be almost all complex carbohydrate (Taskinen, 1986).

Carbohydrates

The use of carbohydrates in the diet has been debated by researchers for years. According to Taskinen (1986), in the 1930's the amount of carbohydrates allowed in the diet accounted for only 15% of total daily calories. Research since that time has indicated that a high carbohydrate low-fat diet may improve diabetic control. However, it has just been since the 1970's that the high carbohydrate diet has been used by diabetics.

The digestability of carbohydrates can be affected by the form, the types of processing, the presence of antinutrients, and starch components (Thorne, Thompson, Jenkins, 1983).

The form the food is in may have an effect on how quickly it is absorbed. In studies by Crapo (1976), liquid foods gave a greater response than their solid counterparts. Bantle, Laine, Castle, Thomas (1983), showed that ground rice gave a larger glycemic response than whole grain rice; and pasta gave a lower response than bread made with the same wheat starch.

The way food is processed may also have an affect on absorption. In a study by Colagiuri, Miller, Holliday, and Phelan (1986), three isocaloric breakfasts were given to eight diabetic patients on three test days in random order. Meal A consisted of boiled eggs, wholemeal toast, margarine, orange juice, whole milk and coffee or tea. Meal B contained two wheatflake biscuits, wholemeal toast and margarine, whole milk, and coffee or tea. Meal C contained toasted musesli, skim milk, and tea or coffee. The meals were all similar in protein, fat, carbohydrate, and dietary fiber. Blood glucose values were taken and compared. Meals A and B had very similar blood glucose responses. Meal C had a blood glucose response that was one half that of A and B. The researchers contributed this effect to the different types of processing the food products had undergone. They stated that since wheat starch in bread is gelatinized and partially digested, it is much more processed than the starch in the rolled oats (a major ingredient in the muesli) which is only partially gelatinized. Also, the wheat flakes are more processed than the rolled oats. They stated the extra processing makes the starch more digestible and may cause the blood sugar level to rise proportionately (Colagiuri, 1986).

Others agree that cooking starch may affect digestibility, with raw starches being less digestible and giving lower glycemic responses than cooked starches. Collings, Williams and McDonald (1981), referred to a study that showed that moist heat methods of cooking starches increased the digestibility over dry heat methods.

Crapo, Reaver and Olefsky (1977) compared the glycemic responses of different types of carbohydrate on normal subjects. Their test substances consisted of dextrose (glucose), potato, bread, rice, and corn which all contained 50 gm of glucose. These researchers found that glucose and potatoes gave similar insulin and glucose responses; and corn, rice, and bread gave lower responses. Their conclusion was that not all complex carbohydrates can be considered the same metabolically, and the responses in normal subjects may be amplified in diabetics. Different starches may differ in digestibility.

Thorne and researchers (1983) state that there may be differences in the digestibility of starches due to their amylose or amylopectin content. Amylopectin has a larger surface area and this may make it more readily digestible. These researchers also state that protein may make starch more indigestible because of interaction between the two. They refer to research by Anderson, Levine, and Heirtt (1981) who demonstrated that the starch in bread was digested quicker when the gluten was removed. Thorne, et al. (1983) also stated that antinutrients such such as phytates, amylase and sucrase inhibitors, and lectins may work to slow starch digestibility.

Mann (1987) reports that the digestion rate of starchy foods may have a big influence on the glycemic response. The faster the starch is absorbed the greater the response it gives. Mann (1987) also states, "Many factors appear to influence starch digestibility including quantity and type of dietary fiber (gel-forming and soluble fibers have a profound effect), presence of antinutrients, particle size, nature of the starch, and interactions between starch and other nutrients. These factors appear to exert these effects through alterations in gastric emptying and small intestine absorption." These factors may slow absorption of glucose into the blood.

Simple Sugars

Another factor that must be carefully controlled in a diabetic diet is the use of simple sugars. In the past, health professionals recommended that no, or very little sugar, be allowed in the diabetic diet. This guideline made compliance to diabetic diets very difficult. Recent research with simple sugars determined certain sugars could be used in conjunction with meals in diabetic diets. Some of the types of sugars tested were: sucrose, glucose (dextrose), and fructose. With all these sugars, response was determined by measuring blood glucose levels after ingestion. Bantle, et al. (1983) fed normal and diabetic subjects equal amounts of carbohydrates in the form of glucose, fructose, sucrose, potato starch and wheat starch. These carbohydrates were eaten with a meal of eggs, bacon, toast, rice cereal, and milk. In normal subjects fructose caused the lowest blood glucose response and glucose the highest response. The sucrose, potato starch, and wheat starch gave intermediate blood glucose responses. In Type I (juvenile onset) diabetic subjects, glucose gave the largest blood glucose response and fructose gave the lowest response. In Type II (adult onset) diabetic subjects, the result was the same as with the Type I diabetics and the normal subjects. Another study by Crapo, Scarkett, and Kelterman (1982) compared fructose and sucrose in the form of cake and ice cream using normal (non-diabetic) subjects. Results indicated that fructose ice cream gave a lower blood glucose response than the sucrose ice cream. The glycemic response to the fructose cake was much lower than the response to the sucrose cake. Bossetti, Kocher, Moranz, and Falko (1984) compared blood lipid, glucose, and insulin levels of normal subjects who incorporated fructose and sucrose into whole meals. They determined that there were no significant differences in the lipid, glucose, and insulin responses between fructose and sucrose. They did, however, think there could have been differences in the levels if diabetic or hypertriglycedimia subjects had been used. All researchers reviewed found that fructose gave a lower blood glucose response than sucrose or glucose. The postulated reason for fructose giving a lower glycemic (blood glucose) response is that fructose uptake in the liver does not require insulin. Long-term ingestion of fructose is reported safe by researchers Pelkonen, Aro, and Nikkila (1972).

The key to adding simple sugars to diets, whether fructose, sucrose, or glucose, is moderation. Small amounts of simple carbohydrates incorporated with meals are acceptable as long as weight is controlled and blood glucose peaks are avoided. Ingestion with protein, fat, and fiber foods may help moderate blood glucose levels. According to Crapo et al. (1976) when sugar is ingested with protein and fat, the glycemic response is lower than that of sugar eaten alone.

The form the food is eaten in also affects the glycemic response. In a study by Shively and Apgar (1986), blood glucose response to solutions of glucose was higher than that of glucose in a solid form. Crapo et al. (1976) demonstrated this same effect when they gave subjects glucose, sucrose, or starch as a drink and as a solid. Overall, the subjects all had lower responses to the solid forms.

Dietary Fiber

Other types of carbohydrates can also affect the blood glucose response. Dietary fibers, a form of complex carbohydrate, is a heterogenous substances with many different components such as cellulose, hemicellulose, pectins, and gums which have different solubilities (Jenkins, Wolever, and Wong, 1984). Some components are water soluble and some are insoluble. The soluble fibers such as pectins and gums are found in oatmeal and legumes. The insoluble fibers are found in wheat bran. There have been several studies involving the effect on glycemic response of these types of fibers. Most early blood glucose studies involved wheat bran as the fiber source. Jenkins et al. (1984) did not show a marked glycemic lowering effect with wheat bran. Murray and Braungardiner (1984) found that when wheat bran was added to meals there was no significant difference in glycemic responses for diets with or without wheat bran in diabetic subjects with artificial pancreas. These subjects also had no net decrease in insulin requirements. Similarly, Jenkins et al. (1984) found the blood glucose responses to white and wheat bread identical. Also, long term use of wheat meal as compared to white bread did not result in a great reduction of blood glucose response. The long term effect of wheat bran on normal subjects was a study done by Villaume, Beck, Garriott, Desalme, and Debry (1984). These researchers found that, after a chronic ingestion of wheat bran for 10 weeks, the subjects had marked reduction in blood glucose and a noticeable hyperinsulinemia. However, Anderson and Ward (1979) showed that larger amounts of wheat bran eaten with a high carbohydrate diet did show a beneficial glucose response. But overall, the best response of lowering blood glucose levels has been with soluble fibers like pectins and gums. This type of fiber can be found in leafy vegetables, oatmeal, fruits and legumes. Guar gum, which comes from legumes, shows a remarkable decrease in postprandial (after eating) blood glucose levels in diabetics and reduces urinary sugar loss. Parsons (1984) reviewed research showing that pectin fiber caused a smoother blood glucose curve in Type II diabetic patients. This effect also occurred when pectins in the form of fruit were combined with wheat bran. Some of the leveling may be a result of the fiber slowing the gastric emptying rate and reducing the small intestine absorption.

The amounts of fiber given seem to matter in glycemic response. Simpson and Mann (1979) fed subjects 97 grams of fiber a day and observed a lowering of fasting blood glucose levels. Other researchers such as Kinmonth and Hollenbeck (1985) fed 50-60 grams of dietary fiber to their subjects.

These large amounts of dietary fiber may lower the glycemic response, but can cause discomfort. In a study by Lindsay, Hardy, and Jarrett (1984), children with Type I diabetes mellitus were placed on a high carbohydrate, high fiber diet for 14 days. The fiber content of the diet was 30 grams of fiber per 1000 calories. The fibers used were both soluble and insoluble types. During this study, the children complained of increased bowel movements, the feeling of being too full, and flatulence. Another study by Story (1985) examined the compliance of diabetic men to high fiber diets. In this study the men ingested 65 gm of dietary fiber per day. They also complained of intestional gas and discomfort. But these men all had good weight maintenance and insulin control when using this diet. They preferred and adhered better to the high carbohydrate, high fiber diet which included their own food preferences and naturally occurring plant and vegetable fibers rather than including larger amounts of refined brans. The American Diabetes Association (1987) has the following recommendations for incorporating fiber into the diet:

> "Fiber supplementation appears to be beneficial only if given with a diet comprising at least 50% of the calories as carbohydrate. Foods should be selected with moderate-to-high amounts of dietary fiber from a wide variety of foods. These foods include legumes, lentils, roots, tubers, green leafy vegetables, all types of wholegrain cereals (e.g., wheat. barley, oats corn and rye) and fruits. Fruits and vegetables should be eaten raw to maximize the fiber effect and not pureed, which causes loss or reduction of the fiber effect.

The American Diabetes Association (1987) also recommends a slow increase in dietary fiber, not a radical increase, to prevent chances of hypoglycemia due to changes in needed insulin amounts.

<u>Glycemic Index</u>

The fact that equal amounts of carbohydrate foods elicit different blood glucose responses led to the development of the glycemic index. The glycemic index is another factor that improved diabetic control. It is a way to determine the biological equivalence of certain carbohydrate foods by setting a reference point on glycemic responses to certain foods. The formula for the glycemic index is a comparison of the blood glucose response to a test food compared to the blood glucose response of a reference food (Jenkins and Wolever, 1981). Originally, pure glucose in water was used as the reference food, but white bread is now used. Bread, though rapidly absorbed from the gut as glucose, is used as the reference food because a glucose solution slows gastric emptying due to its high tonicity. After ingestion of the food, blood glucose is monitored for a period of 2.5 hours and plotted on a curve. The area under the curve is then compared with the area under the curve produced by the reference food (white bread) using this formula (Jenkins and Wolever, 1983):

$$GI = \frac{\text{blood glucose area of test food}}{\text{blood glucose area of reference food}} \times 100$$

Slowly digested foods produce a flatter glycemic response and a lower glycemic index as reported by Jenkins and Wolever (1983). These foods received the term "lente carbohydrate foods". These low response foods include spaghetti, yams, buckwheat, sweet potato, dried legumes, and oatmeal. High response foods that have been tested include cornflakes, rice, instant potatoes, and whole meal bread (Jenkins, 1983; Jenkins, 1986) Studies that reported little effect of high fiber on this glycemic index, used wheat fiber (insoluble fiber) as the fiber source. However, when legumes (containing gums and other soluble fibers) were tested, they resulted in a lower glycemic index.

The glycemic index is fairly accurate for simple, individual foods, but it can be more difficult in predicting the glycemic response of mixed meals which contain carbohydrates, protein, and fat. However, Wolever, Nuttal, and Lee (1985) determined that when the glycemic index is calculated for mixed meals, the proportion of carbohydrate should be calculated separately from each food. This value is multiplied by the glycemic index for that food. Then each of the food glycemic indexes are added together to give meal index (Wolever, 1985). When calculated in this fashion, they stated that the addition of fat and protein to a carbohydrate meal had only a small effect on the glycemic response to carbohydrate containing meals. These researchers demonstrated that when two carbohydrates of different glycemic indexes were incorporated into a meal, the blood glucose response was midway between their values (Wolever, 1985).

Blood Glucose Monitors

One goal of a person with diabetes is to regulate blood sugar levels similar to that of a non-diabetic person. The reason for this is because having "normal" blood sugar levels decreases the chance for diabetic complications such as neuropathy, retinopathy, and nephropathy. Monitoring the blood glucose levels can be done by measuring the glucose concentration in the blood or by measuring urine glucose (Service, O'Brien, and Rizza, 1987). Measuring glucose in the urine is not always a reliable method of determining glycemia. Urine measurements are best for indicating hyperglycemia, and it usually does not provide information on hypoglycemia. Actual measurment of glucose levels in the blood is a more accurate method of determining glycemia. Until recently, the use of blood glucose monitors was restricted to hospitals and clinics. Now there are inexpensive home blood glucose monitors available that diabetics can use with a fair amount of ease and accuracy.

Most home glucose monitors are reflectance photometers which measure a color change in glucose oxidase chemstrips. In this reaction a drop of blood is placed on the "reading" end of the chemstrip, then after a measured amount of time the strips are wiped or rinsed to stop the reaction. The chemstips are inserted in the glucose meter which measures the amount of glucose in milligrams/deciliter. Or, the chemstrips can be compared against a color chart which indicates the approximate amount of glucose in the blood. The total time needed to do a measurement is usually two to five minutes. This is important because diabetics can take several blood glucose tests a day and can control their diet and insulin intake accordingly. Another good thing about blood glucose monitors is they are portable and can be taken almost anywhere (Service, 1987).

Most blood glucose monitors are similar in design and accuracy. In a study by Clarke, Cox, and Gonder-Fredrick (1987), three glucose monitors were compared against the Technician RA-100 autoanalyzer which is used for clinical situations (Clarke, 1987). The three home monitors compared were the Accu-Check II by Boehringer Mannheim, Glucometer II by Ames, and the Glucoscan 9000 by Lifescan. Although all monitors were considered acceptable for clinical use, these researchers determined that the Accu Chek II was more accurate than the other two monitors (Clarke, 1987).

The Meal-On-The-Go Bar

The Meal-on-the-Go Bar is a high fiber meal bar that was developed at Oklahoma State University in the Home Economics Food Product Development Lab and is marketed by the Provesta Corporation. This bar contains both soluble and insoluble fibers in the form of oatmeal, wheat bran, fruit pectins, and whole wheat flour contributing 7 grams of dietary fiber per bar.

A major source of protein in the bar is from a dried torula yeast that is produced by the Provesta Corporation. With this protein added, each Meal-on-the-Go Bar has the protein equivalent of one egg. The nutrient composition of the Meal-on-the-Go Bar is shown in Table I.

TABLE I

NUTRITIONAL ANALYSIS OF THE MEAL-ON-THE GO BAR

315 Calories	76.70 IU Vitamin A	60 mg Calcium
7 gm Protein	0.235 mg Thiamine	233 mg Phospherous
10 gm Fat	0.302 mg Riboflavin	6.7 mg Iron
52 gm Carbohydrates	2.88 mg Niacin	247 mg Sodium
7 gm Dietary Fiber	1.45 mg Ascorbic	396 mg Potassium

The Meal-on-the-Go Bar is also fairly high in simple sugars, mainly sucrose, glucose, and fructose. Even though this bar is high in simple sugars, the fiber content is also high. The research by Jenkins et al. (1986) and Wolever et al. (1985) indicates that mixed high fiber foods may be beneficial in lowering blood glucose levels in diabetics. Simple sugars, when incorporated into meals, may not cause the rapid fluctuations in blood glucose levels as once was thought (Taskinen, 1986; Crapo, 1982; Bosetti, 1984; and Pelkonen, 1972). With this information, the Meal-on-the-Go Bars should be tested for possible use in diabetic diets.

CHAPTER III

RESPONSE OF BLOOD GLUCOSE LEVELS TO VARIATIONS OF THE MEAL-ON-THE-GO BAR

Introduction

Food technologists are responsible for developing food products which meet the needs of varying individuals. This includes people who have health problems where diet may be an important factor in controlling their health problems. It is important that the food technologists learn as much as possible about a specific disease to best cater to the needs of those with that problem.

Diabetes is a widespread, prominent disease condition in the United States and accounts for a large number of deaths each year. The following statistics were taken from Diabetes Facts and Figures by the American Diabetes Association (1987):

(1) Diabetes is a leading cause of death by disease in the U.S. killing 300,000 people each year;

(2) Each year 5,000 people lose their sight because of diabetes;

(3) Diabetic eye disease is the number one cause of new blindness in people between the ages of 20 and 74;

(4) Ten percent of all people with diabetes develop kidney disease;

(5) Nearly 25 percent of all new dialysis patients are people with diabetes;

(6) About 45 percent (or more than 30,000) of all non-traumatic leg and foot amputations in the U.S. are caused by diabetes;

(7) People with diabetes are 2 to 4 times more likely to have heart disease;

(8) People with diabetes are 2 to 6 times more likely to have a stroke;

(9) Diabetes can lessen the chance of a successful pregnancy and increases the risk of birth defects;

(10) Direct and indirect costs for diabetes run $14 billion annually and account for 3.6 percent of total U.S. health costs.

There are many complications that can occur with this disease including neuropathy, nephropathy, and retinopathy (2). If blood sugar levels are controlled, many of these complications can be lessened. One way of controlling the blood sugar level is by diet. The diet recommendations for a person with diabetes are as follows: Protein calories should account for 15 to 20 percent of total intake; fat calories are to be no greater than 30 to 35 percent of total intake, mainly mono and polyunsaturated with saturated fats limited; the amount of carbohydrate recommended is 55 to 60 percent of the total energy of the diet (2).

With these diet recommendations, other factors must also be considered. This includes the digestability of carbohydrates, the use of simple sugars, and the types of dietary fiber needed in the diet (3). According to Mann (4), different carbohydrates can have different digestability rates depending on the form, the amount of processing of the carbohydrate, and the presence of antinutrients.

The use of simple sugars in diabetic diets was not recommended in the past, but research indicates that, when simple sugars are incorporated into a meal that contains protein and fat, the glycemic response is less than the same simple sugars taken alone (5). Also, fructose seems to give a lower glycemic response than either gluose or sucrose (5).

Dietary fiber may also be important for diabetics. Studies by Jenkins, Wolever and others (6, 7, 8) indicate that the type of fiber consumed may have an effect on the glycemic response. Soluble fibers such as pectins and gums seem to give lower blood glucose responses than insoluble fibers (5).

The Meal On-the-Go Bar is a high fiber, light meal replacement developed at Oklahoma State University and marketed by the Provesta Corporation. This bar contains soluble fibers in the form of oatmeal and insoluble fibers from wheat bran and whole wheat flour. This bar also contains simple sugars in the form of fructose, sucrose, and glucose.

Materials and Methods

Students and faculty from Oklahoma State University volunteered to serve as subjects in this study. These included five females (ages 24-54) and three males (ages 22-29) for a total of eight subjects (Appendix A, Subject Consent Form).

A standard glucose tolerance test (GTT) was performed using 50 gm of glucose and 500 ml of liquid in the form of Glucola, a standardized beverage widely used in glucose tolerance tests. They were allowed 15 minutes to consume the entire Glucola. The GTT was to determine if the subjects had a "normal" range of fasting blood glucose and to chart their glucose glycemia responses. The test was performed by testing blood from fingerprick at eight time intervals following the glucose challenge. All subjects in this study had to have a fasting blood glucose level in the range of 65-120 mg/dl. Subjects were tested in groups of no larger than three with each subject being tested no more often than on every second day. Subjects were told to fast for 12 hours before the test period.

Three bars were tested: the Meal-On-the-Go Bar, fructose bar, and an iso-bar. The Meal-On-the-Go Bar was a high fiber meal bar that contained 7 gms of combined soluble and insoluble fiber in the form of wheat bran, whole wheat flour, oatmeal and fruit pectin. An 80 gm portion of this bar contains 7.7 gm of protein, 8.61 gm of fat and 50 gm of carbohydrate (see Table II).

The fructose bar was similar to the Meal-On-the-Go Bar for fat, protein, total carbohydrates and fiber. Total grams of simple sugar from Frodex, (a dextrose dextrin blend), brown sugar, and high fructose corn syrup were replaced with crystalline fructose (Staley Company). The other ingredients were identical to the Meal-On-the-Go Bar. The serving given to the subjects contained 50 gm carbohydrate.

TABLE II

MEAL-ON-THE GO BAR COMPARISON

Carbohydrate Contents	Grams
Complex	
Wheat flour (all purpose white)	9.0
Whole wheat flour	3.0
Wheat bran	2.0
Fruit carbohydrates	6.0
Oatmeal	9.0
Simple	
Brown sugar (sucrose)	12.0
Frodex	
higher sugars	4.0
glucose	0.6
dextrins	0.4
High fructose corn syrup	
Sucrose	2.0
Fructose	1.0
Glucose	1.0
TOTAL	50.0

The iso-bar contained the same amount of protein (egg albumin), fat (vegetable oil) and carbohydrate (glucose) as the Meal-On-the-Go Bar and the fructose bar, but that was the only similarity to the other two bars. This "bar" was made with crystalline glucose that was gradually beaten into the egg whites. Then the vegetable oil was folded into the stiffly beaten mixture. The "bars" were baked in a 275^{o} oven for 20 minutes. Due to the hygroscopic nature of the sugar, these bars were transferred to a food dehydrator at 140^{o}F until completely dry then held in the dehydrator at 90^{o}F until given to the subjects. A comparison of the contents of all four feeding treatments is given in Table III.

On test days the bars were given randomly to the subjects, and they were allowed 15 minutes to consume them along with 500 ml of water. Thus, the test foods all contained 50 gm carbohydrate and were ingested as rapdily and with the same volume of liquid as in the GTT.

Testing took place in a controlled environment, and subjects were instructed to minimize activity. Blood glucose samples were taken via fingerprick at times 0, 15, 30, 45, 60, 90, 120 and 150 minutes. Each subject had individual Autolances and disposable lancets for fingerpricks. The Autolances were cleaned in a disinfectant solution of dilute sodium hypochlorite after each testing period. Before the study the subjects were asked to wash their hands under warm water to prevent infection or test contamination and to increase circulation of blood. Also, alcohol swabs were used before and after finger pricking.

TABLE III

CARBOHYDRATE, FAT AND PROTEIN CONTENT (IN GRAMS) OF TREATMENTS

	Treatments			
Components	Glucose In Solution	Meal-On-the-Go Bar	Fructose Bar	Iso-Bar
Carbohydrates				
Simple	50.00	21.00	21.00	50.00
Complex	0.00	29.00	29.00	0.00
Total	50.00	50.00	50.00	50.00
Fat	0.00	8.61	8.61	8.61
Protein	0.00	6.73	6.73	6.73

The experiment was conducted as a split plot in time where the three treatments were applied in random order to each subject and compared with the results of the GTT (see Table IV). (The original design was a 3 x 3 factoral arrangement of treatments in a randomized block design, where subjects were grouped into three blood glucose response levels based on the glucose tolerance tests, with three treatments [Meal-On-The Go Bar, Fructose Bar, and Iso-Bar]. Each testing day was a randomized complete block. One subject dropped out of the study before completion, so the data were analyzed as described above. A more detailed description of the original design is in the Appendix B.) Blood glucose samples were taken beginning at 8:00 and extending through 10:30 a.m. The treatment tests followed the same time increments as the GTT. Results were analyzed using Analysis of Variance and Least Significant Difference tests with an alpha level established at $p = 0.05$.

TABLE IV

TREATMENT ORDER

		TREATMENT DAYS		
Subjects	Pretest	Day 1	Day 2	Day 3
1	GTT	MG	FB	IB
2	GTT	IB	MG	FB
3	GTT	FB	IB	MG
4	GTT	MG	FG	IB
5	GTT	IB	MG	FB
6	GTT	FB	IB	MG
7	GTT	MG	FB	IB
8	GTT	IB	MG	FB

MB = Meal-On-the-Go Bar
IB = Iso-Bar
FB = Fructose Bar
GTT = Glucose Tolerance Test

Instrumentation

Blood glucose levels were determined using Chemstrips (Boehringer Mannheim). The Chemstrips contain glucose oxidase which undergoes a color change proportional to the blood glucose concentration. The Accu-Chek II (Boehringer Mannheim) is a reflectance photometer which measures the color range of the chemstrips. This gives precise results, demonstrating excellent agreement (r=0.994) with the hexokinase reference method in the 20-500 mg/dl range (9). A finger prick sample was taken at each time period for each sample and a hanging drop of blood was smeared on the Chemstrips. The time button was pressed on the Accu-Chek II blood glucose monitor which counted to 60 seconds. At the end of the 60 seconds, the machine emitted a beep; and the strips were wiped with cotton balls to remove all blood and stop the reaction. The strips were then inserted into the reading part of the monitor; and, at the end of another 60 seconds, it gave the blood glucose reading in mg/dl (miligrams of glucose per 100 milliliters of whole blood).

Results

The blood glucose values were averaged at each testing time for all subjects for each product. The results of the F-tests (see Appendix B) showed that there was an interaction of time and treatment; therefore, the comparisons were made at times: 0, 30, 60, 90, 120 and 150 minutes (but not across time). At time 0 there was not a significant difference in responses among treatments. At time 30 the Iso-Bar and glucose solution were significantly higher than the Meal-On-the-Go Bar and the fructose bar. At time 60 there was still a significant difference between the fructose bar and the iso-bar but no differences in the iso-bar and the regular (Meal-On-the-Go) bar or the regular bar and the fructose bar. The glucose response was significantly higher than the other treatments. At time 90 there was a near but not significant difference between the fructose bar and the iso-bar, with the iso-bar giving the lower response. There were no significant differences in the responses between the regular bar and the fructose bar and between the iso-bar and the regular bar, but the iso bar and Meal-On-the-Go Bar were significantly diffrerent from glucose. At time 120 the fructose bar was significantly lower than glucose. At time 150 there were no significant differences in any of the products. These results are shown in Table V and Figure 1.

The iso-bar gave both the sharpest peak and the lowest drop. These occurred at times 30 and 90, respectively. The fructose bar, overall, gave the most moderate response.

The subjects in this study had highly individualized and varied blood glucose responses. This can be seen in Figure 2. These subjects were considered "normal," and all had fasting blood glucose levels which fell in the normal range of 65-120 mg/dl. As might be expected, the standard deviations for the different treatments at the six testing times reflected the wide variation of responses of the subjects to the treatments. Table VI shows these treatment means and standard deviations. (See Appendix B for Class Level Information and Analysis of variance; see Appendix D for the Raw Data.)

TABLE V

MEAN BLOOD GLUCOSE READINGS FOR ALL TREATMENTS AT 30 MINUTE INTERVALS

Treatment	Time (in minutes)				
	30	60	90	120	150
Glucose	150.25a	132.50a	99.37a	77.87ab	79.25a
Iso-Bar	148.12a	106.25b	73.62b	73.37b	79.12a
Meal-On-the Go Bar	130.25b	93.87bc	78.87b	81.00ab	83.75a
Fructose Bar	124.00b	91.50c	86.37ab	87.50a	83.87a

n =8
a,b,c = means followed by different letters are significantly different ($P \leq 0.05$), LSD = 14.09.

Conclusions

These data indicate that there is a significant difference between the iso bar and the Meal-On-the-Go Bar at several time increments with the iso-bar starting higher, then falling lower. Differences between these two

TABLE VI

TREATMENT MEANS AND STANDARD DEVIATIONS
OF BLOOD GLUCOSE RESPONSES
AT EIGHT TIMES

Level of Treatment	Level of Time	Blood Glucose Response Mean	Standard Deviation
fructose	0	84.00	7.98
fructose	15	97.62	10.64
fructose	30	124.00	14.50
fructose	45	104.87	23.93
fructose	60	91.50	17.01
fructose	90	86.37	12.83
fructose	120	87.50	15.38
fructose	150	83.87	9.64
glucose	0	76.00	8.83
glucose	15	108.50	23.65
glucose	30	150.25	8.24
glucose	45	134.25	25.49
glucose	60	132.50	24.66
glucose	90	99.37	51.55
glucose	120	77.87	42.35
glucose	150	79.25	24.59
iso-bar	0	80.50	6.21
iso-bar	15	105.50	17.35
iso-bar	30	148.12	24.42
iso-bar	45	139.87	17.24
iso-bar	60	106.25	31.44
iso-bar	90	73.62	12.39
iso-bar	120	73.37	13.65
iso-bar	150	79.12	12.19
MGB*	0	81.26	5.99
MGB	15	107.12	27.13
MGB	30	130.25	19.51
MGB	45	114.62	23.71
MGB	60	93.87	20.79
MGB	90	78.87	10.77
MGB	120	81.00	3.70
MGB	150	83.75	8.54

*MGB (Meal-On-the-Go Bar)

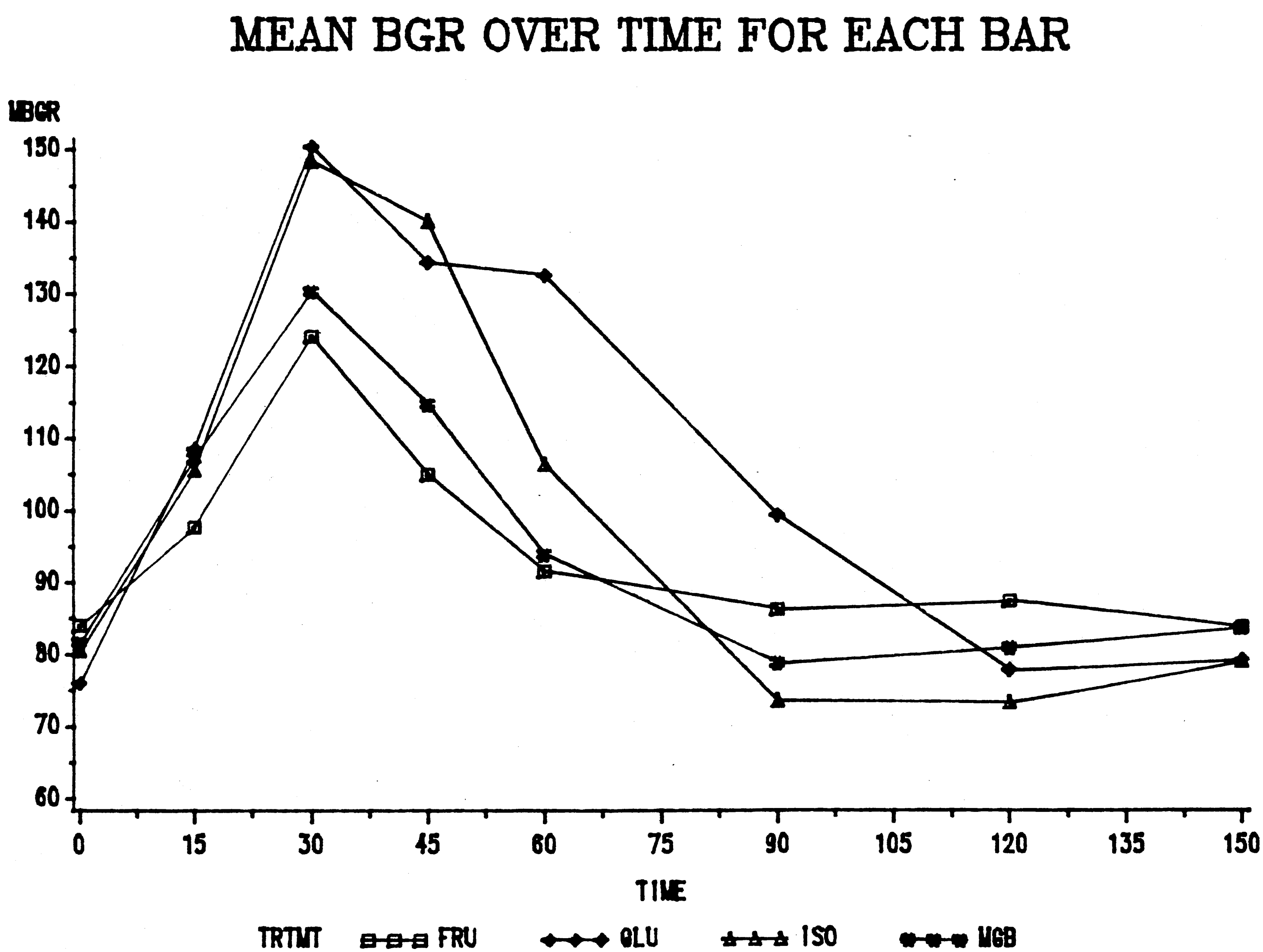


Figure 1. Mean Blood Glucose Response Over Time for Each Bar.

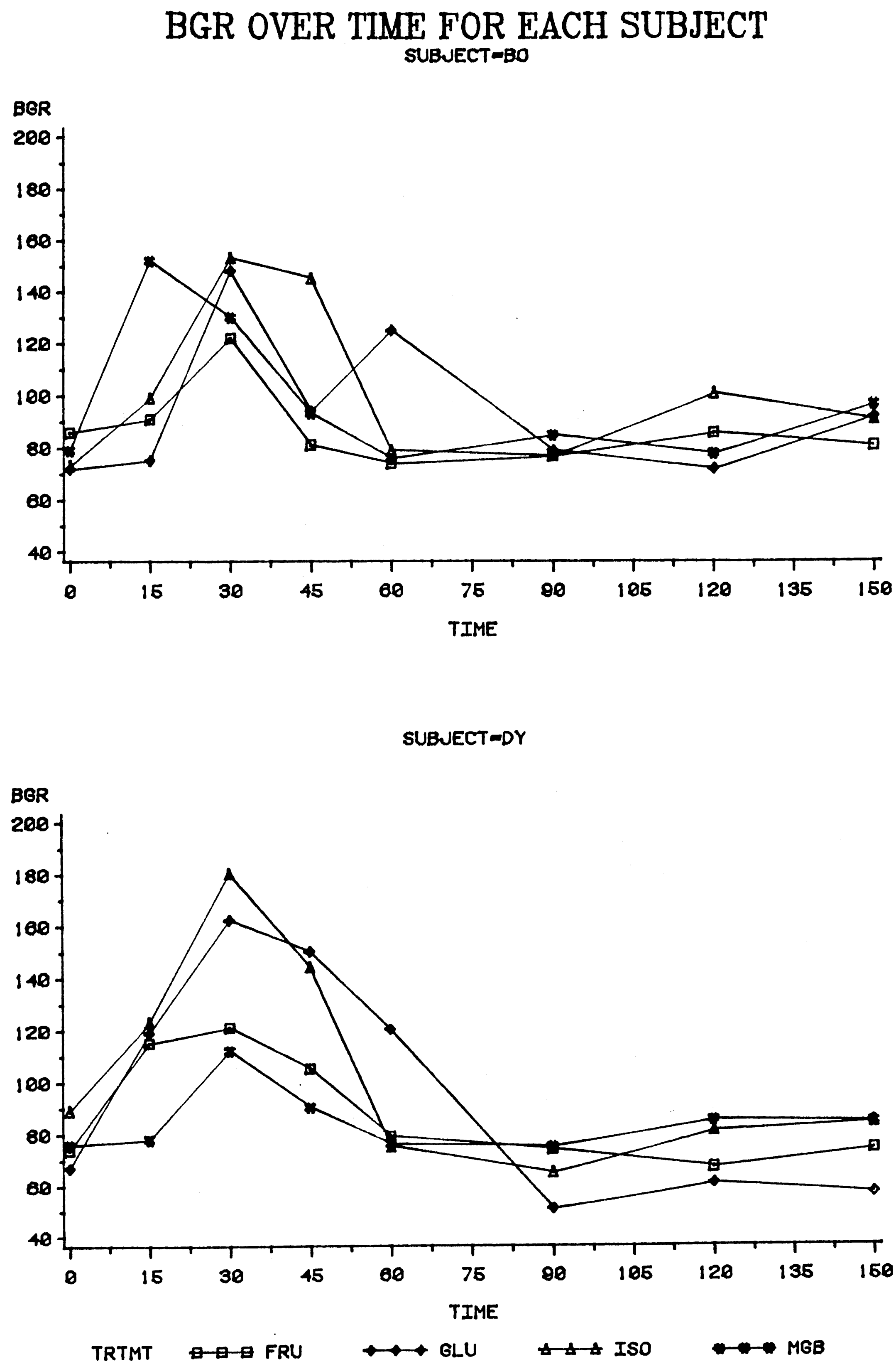


Figure 2. Blood Glucose Response Over Time for Each Subject.

BGR OVER TIME FOR EACH SUBJECT

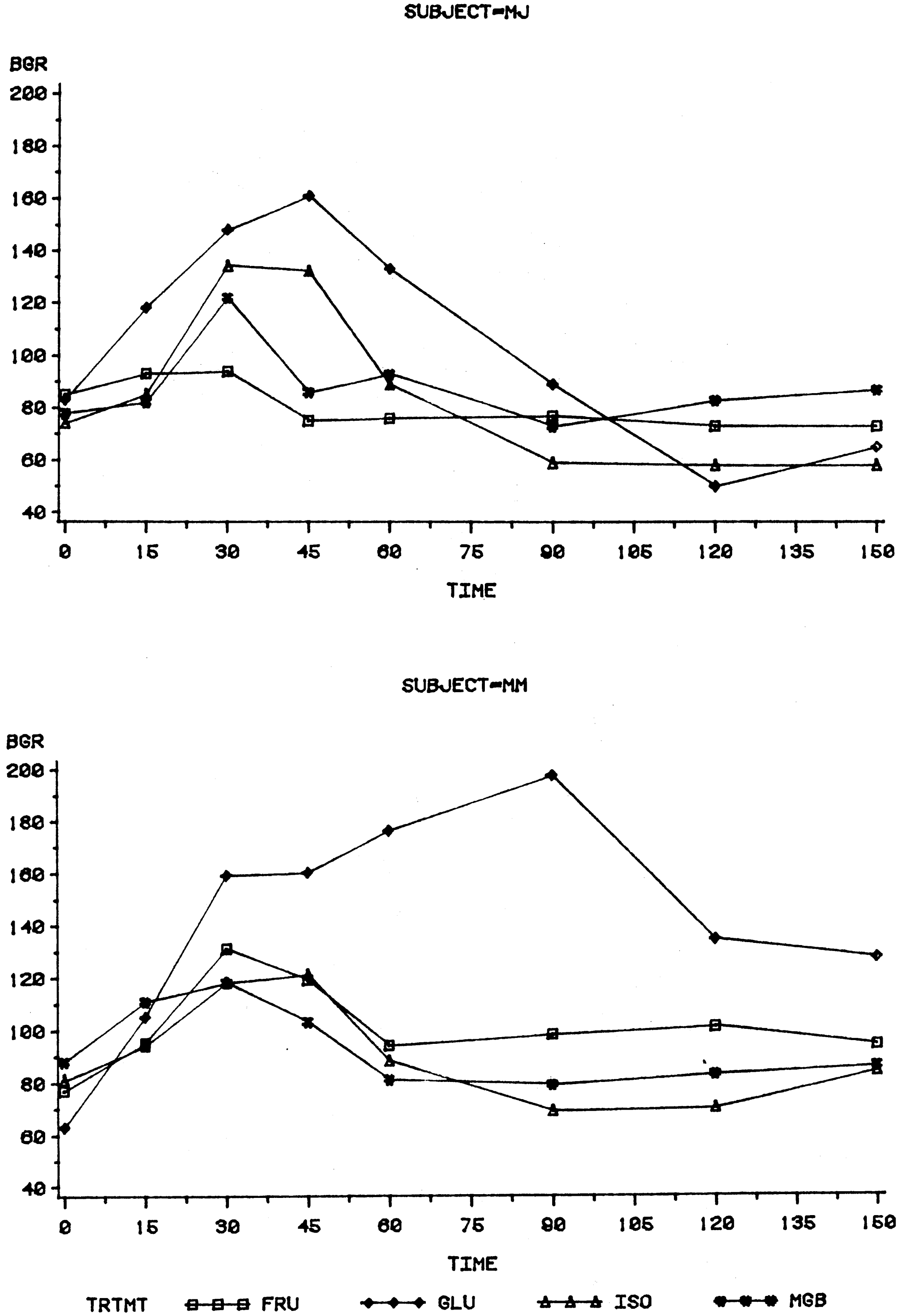
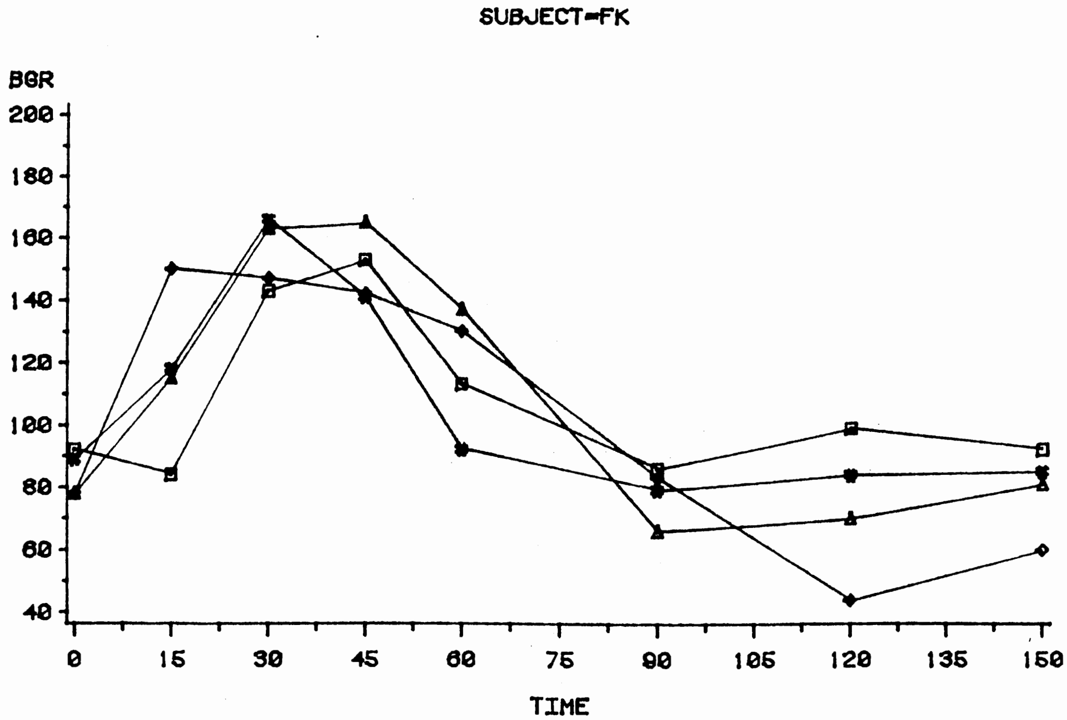


Figure 2. Continued.

BGR OVER TIME FOR EACH SUBJECT



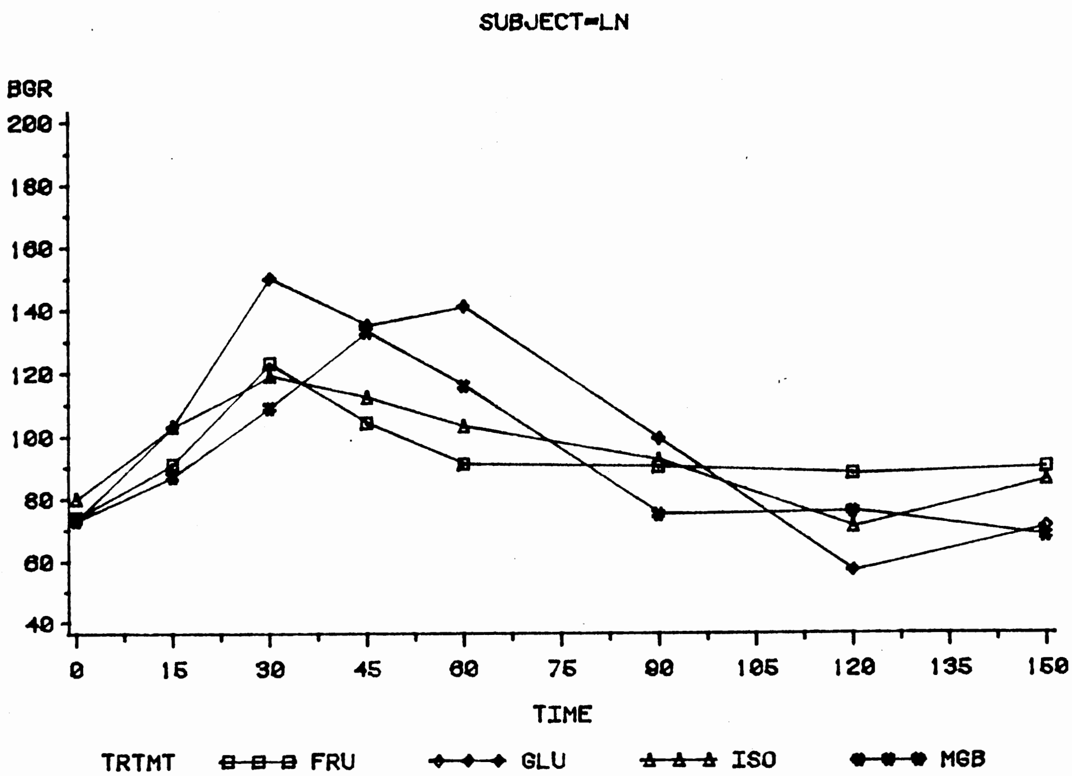


Figure 2. Continued.

BGR OVER TIME FOR EACH SUBJECT

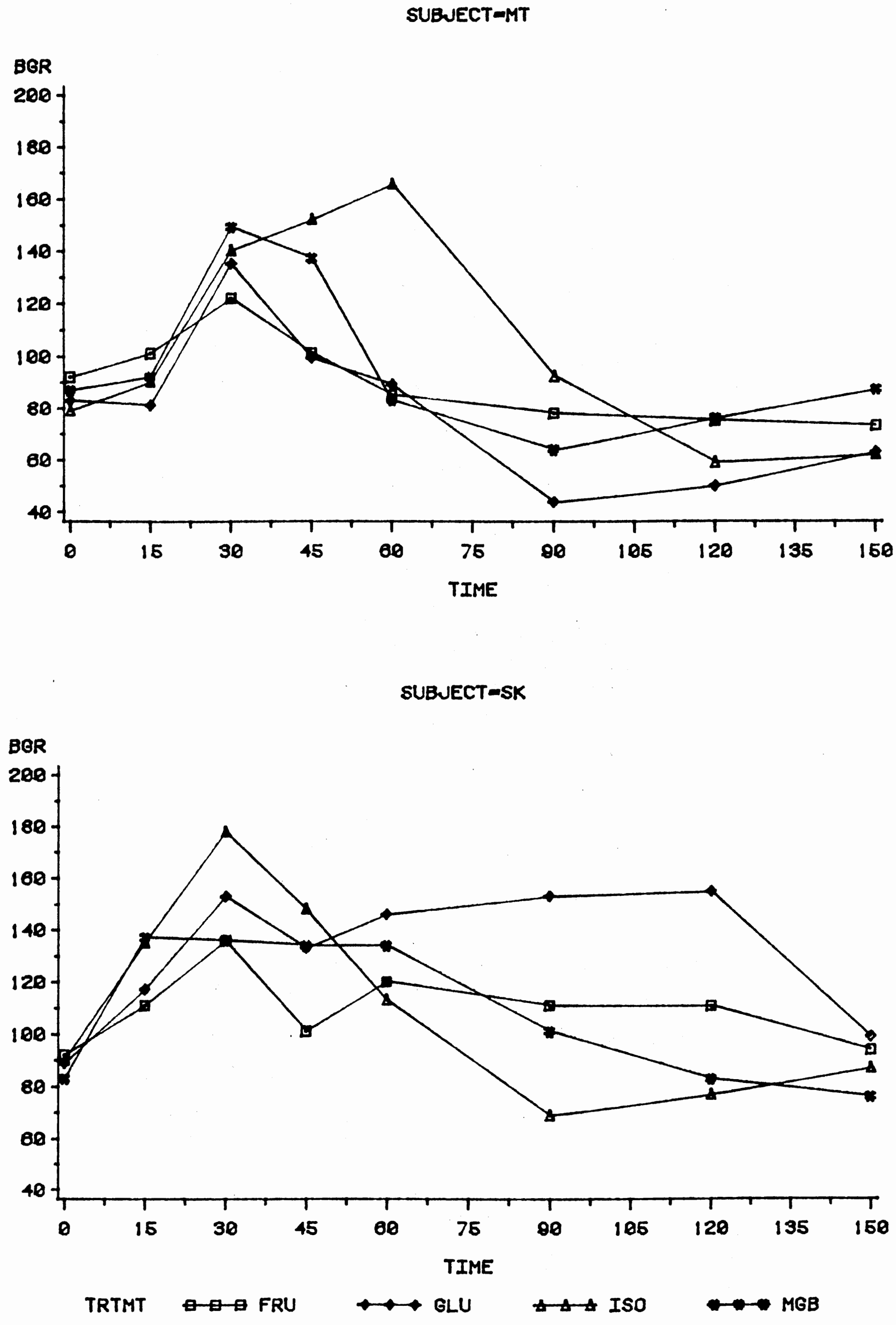


Figure 2. Continued.

bars may have been due to the fiber that was present in the Meal-on the Go Bar; the Meal-On-the Go Bar had a more moderate response. Fiber may have slowed the absorption rate of sugars into the blood by slowing down the digestion rate. This tends to confirm work by Thorne (4). At all times, there was no significant difference between the Meal-On-the-Go Bar and the high fructose bar. This indicates that replacing sucrose and glucose with fructose did not significantly change the glycemic response. This is contradictory to Crapo's studies which found that when fructose was compared against sucrose in a food product, the blood glucose response was significantly lower (9, 10). There were also significant differences between the iso-bar and the high fructose bar at several time increments. There was not a significant difference in the glucose and iso-bar at most time increments which indicates that the protein and fat did not slow the absorption of glucose. This also differs from the research done by Crapo and others (3, 8, 9, 10) who found differences in glucose responses due to the presence of fat and protein.

The different subjects also gave widely varied responses. Therefore, it would be better for this type of testing to use more than eight subjects to receive a better perception of the "norm".

BIBLIOGRAPHY

CHAPTER III

(1) American Diabetes Association: Diabetes facts and figures. American Diabetes Association, Inc. 1986.

(2) Krause, L.M. and Mahan, J.O.: Nutrition and Dietetics. New York, McMallin Publishing Co., 1985.

(3) Thorne, M. J., Thompson, L. V. and Jenkins, D. .: Factors affecting starch digestibility and the glycemic response with special reference to legumes. American Journal of Clinical Nutrition 38: 481, 1983.

(4) Mann, J.: Complex carbohydrates: Replacement energy for fax or useful in their own right? American Journal of Clinical Nutrition 45: 1202, 1987.

(5) Crapo, P. A.: Plasma glucose and insulin responses to orally administered simple and complex carbohydrates. Diabetes 25: 741, 1976.

(6) Jenkins, D. J. and Wolever, T. M.: Glycemic response to wheat products: Reduced response to past but no effect of fiber. Diabetes Care 6: 155, 1983.

(7) Jenkins, D. J. and Wolever, T. M.: Low glycemic response to traditionally processed wheat and rye products: Bulgar and pumpernickel bread. American Journal of Clinical Nutrition 43: 516, 1986.

(8) Crapo, P. A., Reaven, M. G., and Olefsky, J.: Post prandial plasma-glucose and insulin responses to different complex carbohydrates. Diabetes 26: 1178, 1977.

(9) Accu-Chek II, Boehringer Mannheim Diagnostics, 1986.

(10) Crapo, P.A., Scarkett, J.A. and Kolterman, O. G.: Comparison of the metabolic responses to fructose and sucrose sweetened foods. American Journal *of Clinical Nutrition* 36: 256, 1982.

CHAPTER IV

CONCLUSIONS, HYPOTHESIS TESTING AND RECOMMENDATIONS

Conclusions

These data indicate that there are a significant difference between the iso bar and the Meal-On-the-Go Bar at several time increments with the iso-bar starting higher, then falling lower. Differences between these two bars may have been due to the fiber that was present in the Meal-on the Go Bar; the Meal-On-the Go Bar had a more moderate response. Fiber may have slowed the absorption rate of sugars into the blood by slowing down the digestion rate. This tends to confirm work by Thorne (1983). At all times analyzed, there were no significant difference between the Meal-On-the-Go Bar and the high fructose bar. This indicates that replacing sucrose and glucose with fructose did not change the glycemic response. This differs from Crapo's studies (1976, 1977, 1982) which found that when fructose was compared against sucrose in a food product, the blood glucose response was significantly lower. There were also significant differences between the iso-bar and the high fructose bar at several time increments. There was not a significant difference in the glucose and the iso-bar at most time increments which indicates that the protein and fat did not slow the absorption of glucose. this also differs from the research done by Crapo and others who found differences in glucose responses due to the presence of fat and protein.

The different subjects also gave widely varied responses. Therefore, it would be better for this type of testing to use more than eight subjects to receive a better perception of the "norm."

Hypothesis Testing

The hypothesis for this study is as follows:

HO: There are no differences among glycemic responses of subjects due to 50 gm of carbohydrate as:

A. Meal-On-the-Go Bar

B. Iso-bar

C. Fructose Bar

D. Liquid Glucose

Although the Meal-On-the Go Bar and the fructose bar were not significantly different at any of the measured time levels, there were differences among the treatments at every time level except for 0 and 150 minutes. Therefore, the researcher rejects the hypothesis.

In summary, the treatments with fiber were different from the treatments without fiber in that they seemed to cause a more moderate glycemic response. However, fat and protein seemed to have no affect in moderating response in the subjects.

Recommendations

The following recommendations are made for this study:

1) Further studies should involve more subjects to give a better representation of the normal population's response.

2) Blood glucose testing should be done with the Meal-On-the-Go Bar in which different components of the bar are removed and tested to determine if there is a synergistic effect that gives a lowered blood glucose response.

3) The individual fiber sources from the Meal-On-the-Go Bar could be individually tested against the whole bar to determine which fiber component best lowers blood glucose levels.

4) Type II (non-insulin dependent) diabetic subjects might be tested in this type of study involving the Meal-On-the-Go Bar if the testing conditions were carefully controlled, where insulin levels and blood sugar levels were constantly monitored by qualified personnel. This would give a more accurate picture of blood glucose responses among Type II diabetics with this type of high fiber, high carbohydrate food.

BIBLIOGRAPHY

American Diabetes Association (1986). Diabetes Facts and Figures, American Diabetes Association, Inc.

American Diabetes Association (1987). Nutritional recommendations and principles for individuals with Diabetes Mellitus: 1986. Nutrition Today, 87:29-35.

Anderson, I.H., Levine, A.S., Heirtt, M.D. (1981). Incomplete absorption of carbohydrate in all-purpose wheat flour. New England Journal of Medicine, 304:891-898.

Anderson, J.W. and Ward, K.I. (1979). High carbohydrate high-fiber diets for insulin-treated men with Diabetes Mellitus. American Journal of Clinical Nutrition, 32:2312-2319.

Bantle, J.P., Laine, D.C., Castle, G.W., Thomas, W.J. (1983). Postprandial glucose and insulin responses to meals containing different carbohydrates in normal and diabetic subjects. New England Journal of Medicine, 309:7-14.

Bossetti, B.M., Kocher, L.M., Moranz, J.F., Falko, J.M. (1984). The effects of psychologic amounts of simple sugars in lipoprotein, glucose, and insulin levels in normal subjects. Diabetes Care, 7:309-317.

Clarke, W.L., Cox D., and Gonder-Frederick, L.A. (1987). Evaluating clinic accuracy of systems for self-monitoring of blood glucose. Diabetes Care, 10:622-629.

Colagiuri, S., Miller, J.J., Holliday, J.L., & Phelan, E. (1986). Comparison of plasma glucose, serum insulin, and c. peptide responses to three isocaloric breakfasts in non-insulin dependent diabetic subjects, Diabetes Care, 41:250-259.

Collings, P., Williams, C., & MacDonald, I. (1981). Effect of cooking on serum glucose and insulin responses to starch. British Medical Journal, 282:1032-1038.

Crapo, P.A. (1976). Plasma glucose and insulin responses to orally administered simple and complex carbohydrates. Diabetes, 25:741-747.

Crapo, P.A., Reaven, G. & Olefsky, J. (1977). Post prondiani plasma-glucose and insulin responses to different complex carbohydrates. Diabetes, 26:1178-1186.

Crapo, P.A., Scarkett, J.A., & Kolterman, O.G. (1982). Comparison off the metabolic responses to fructose and sucrose sweetened foods. American Journal of Clinical Nutrition, 36:256-262.

Dorland Medical Dictionary, (1982). W.B. Sanders Co.

Jenkins, D.J. & Wolever, T.M. (1981). Glycemic index of foods: A psysiological basis for carbohydrate exchange. American Journal of Clinical Nutrition, 34:362-369.

Jenkins, D.J. & Wolever, T.M. (1983). Glycemic response to wheat products: Reduced response to pasta but no effect on fiber. Diabetes Care, 6:155-160.

Jenkins, D.J. & Wong, G.S. (1984). Glycemic response to foods: Possible differences between insulin-dependent and non-insulin dependent diabetics: American Journal of Clinical Nutrition, 40:971-980.

Jenkins, D.J. & Wolever, T.M. (1986). Low glycemic response to traditionally processed wheat and rye products: Bulgar and pumpernickel bread. American Journal of Clinical Nutrition, 43:516-524.

Kinmouth, C.B. & Hollenbeck, M.R. (1985). the effects if subject-selected high carbohydrate, low fat diets on glycemic control in insulin dependent Diabetes Mellitus. American Journal of Clinical Nutrition, 41:293-298.

Krause, L.M. & Mahan, J.O. (1985). Nutrition and Dietetics. New York: McMallan Publishing Company.

Lindsay, A.N., Hardy, S. & Jarrett, L. (1984). High-carbohydrate, high-fiber diet in children with Type I Diabetes Mellitus. Diabetes Care, 7:64-68.

Mann, J.: Complex carbohydrates: Replacement energy for fat or useful in their own right? American Journal of Clinical Nutrition, 45:1202-1208.

Murray, J.A., & Baumgardner, B. (1984). A high wheat bran diet in insulin-threatened Diabetes Mellitus: Assessment with the artificial pancreas. Diabetes Care, 7:211-219.

Parsons, S. (1984). Effects of high fiber breakfasts on glucose metabolism in non-insulin dependent diabetics. American Journal of Clinical Nutrition, 40:66-72.

Pelkonen, R., Aro, A., & Nikkila, E. (1972). Metabolic effects of dietary6 fructose in insulin dependent diabetes of adults. Actu Medicus, 542:187-194.

Service, J.F., O'Brien, P.C., & Rizza, R.A. (1987). Measurements of glucose control. Diabetes Care, 10:225-228.

Shively, C., & Apgar, J.L. (1986). Postprandial glucose and insulin responses to various snacks of equivalent carbohydrate content in normal subjects. American Journal of Clinical Nutrition, 43:335-341.

Simpson, R. & Mann, J. (1979). High-carbohydrate diets and insulin dependent diabetics. British Medical Journal, 4:523-529.

Stevens, R.E. (1978). Medical Dictionary, New York: McMallan Publishing Co.

Story, L. (1985). Adherence to high carbohydrate, high fiber diets; long-term studies of non-obese diabetic men. Journal of the American Dietetic Association, 85:124-129.

Taskinen, M.R. (1986). Effects of dietary carbohydrates in metabolic disturbances in man. Progressive Biochemistry Pharmocology, 21:160-165.

Thorne, M.J., Thompson, L.V. & Jenkins, D.J. (1983). Factors affecting starch digestibility and the glycemic response with special reference to legumes. American Journal of Clinical Nutrition, 38:481-486.

Villaume, C., Beck, B., Gariot, P., Desalme, A., & Debry, G. (1984). Long-term evolution of the effect of bran ingestion on meal induced glucose and insulin responses in healthy man. American Journal of Clinical Nutrition, 40:1023-1033.

Wolever, T.M., Nuttal, F.Q., & Lee, R. (1985). Prediction of the relative blood glucose response of mixed meals using the white bread glycemic index. Diabetes Care, 8:418-424.

APPENDIX A

SUBJECT CONSENT FORM

STATEMENT TO SUBJECTS

This research will be done to determine if different factors (fructose and fiber) effect the blood glucose response in normal subjects. Subjects will be required to eat four different test meals each followed by blood testing. Subjects will furnish samples via finger prick and one or two drops of blood will be taken at times 0, 15, 30, 45, 60, 90, 120 and 180 minutes. The test meals are as follows:

1. Glucose and water.
2. High fiber Meal-on-the-Go bars and water.
3. High fructose Meal-on-the-Go bars and water.
4. Iso-Bars made with egg whites, glucose and vegetable oil and water.

The subject must agree not to drink alcoholic beverages nor eat anything after 8:00 p.m. before the test days. The research project will be closely monitored and controlled. And during this research project the subject has the right at any time to withdraw. If you agree to be a subject in this research project sign on the bottom line of this form.

______________________________ ____________

Signature Date

APPENDIX B

ORIGINAL RESEARCH DESIGN

RESEARCH DESIGN

The experimental design for this study is to be a randomized block design in a 3 X 3 factorial arrangement consisting of three types of bars. The bars are regular Meal-on-the-Go bars, the high fructose Meal-on-the-Go bars and Iso-Bars made with the same amount of protein, fat, and carbohydrate as the regular Meal-on-the-Go bars. For this study there are to be three groups of subjecst, three treatments on three different days. Multiple linear regression is to be used in this study.

The following is the design for this study.

	Group 1				Group 2				Group 3		
	Day				Day				Day		
	1	2	3		1	2	3		1	2	3
L	A	B	C	L	B	C	A	L	C	A	B
M	C	A	B	M	A	B	C	M	B	C	A
H	B	C	A	H	C	A	B	H	A	B	C

Treatments:

A = Regular Meal-on-the-Go bars

B = High fructose Meal-on-the-Go bars

C = Iso-Bars

Glucose Tolerance Test Values from the nine subjects.

L = Low blood glucose levels of three subjects

M = Medium blood glucose levels of three subjects

H = High blood glucose values levels of three subjects

Days: *

1 = First test day

2 = Second test day

3 = Third test day

* These test days will on alternating days (ie. Tuesday and Thursday).

APPENDIX C

CLASS LEVEL INFORMATION

AND ANALYSIS OF VARIANCE PROCEDURE

ANALYSIS OF BLOOD GLUCOSE DATA ** ALL 4 TREATMENTS
TEST EACH OF THE EFFECTS: TRTMT, TIME AND TRTMT*TIME
USING THE 'SUBJECT*EFFECT' ROW AS AN ERROR TERM

Analysis of Variance Procedure
Class Level Information

Class	Levels	Values
SUBJECT	8	bo dy fk ln mj mm mt sk
TRTMT	4	fru glu iso mgb
TIME	8	0 15 30 45 60 90 120 150

Number of observations in data set = 256

ANALYSIS OF BLOOD GLUCOSE DATA ** ALL 4 TREATMENTS
TEST EACH OF THE EFFECTS: TRTMT, TIME AND TRTMT*TIME
USING THE 'SUBJECT*EFFECT' ROW AS AN ERROR TERM

Analysis of Variance Procedure

Dependent Variable: BGR

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	255	230222.35937500	902.83278186	.	.
Error	0	.	.		
Corrected Total	255	230222.35937500			

Source	DF	Anova SS	Mean Square	F Value	Pr > F
SUBJECT	7	17371.35937500	2481.62276786	.	.
TRTMT	3	5852.82812500	1950.94270833	.	.
SUBJECT*TRTMT	21	18402.42187500	876.30580357	.	.
TIME	7	109568.85937500	15652.69419643	.	.
SUBJECT*TIME	49	18246.14062500	372.37021684	.	.
TRTMT*TIME	21	18018.67187500	858.03199405	.	.
SUBJECT*TRTMT*TIME	147	42762.07812500	290.89849065	.	.

Tests of Hypotheses using the Anova MS for SUBJECT*TRTMT as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
TRTMT	3	5852.82812500	1950.94270833	2.23	0.1150

Tests of Hypotheses using the Anova MS for SUBJECT*TIME as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
TIME	7	109568.85937500	15652.69419643	42.04	0.0001

Tests of Hypotheses using the Anova MS for SUBJECT*TRTMT*TIME as an error term

Source	DF	Anova SS	Mean Square	F Value	Pr > F
TRTMT*TIME	21	18018.67187500	858.03199405	2.95	0.0001

APPENDIX D

RAW DATA

TRANSPOSED DATA SET (1 OBS'N FOR EACH SUBJECT AND TRTMT)
T1-T8 DENOTE BGR'S AT TIME=0,15,30,45,60,90,120,150 MIN

OBS	SUBJECT	TRTMT	NAME	T1	T2	T3	T4	T5	T6	T7	T8
1	bo	fru	BGR	86	91	122	81	74	77	86	81
2	bo	glu	BGR	72	75	148	94	125	79	72	92
3	bo	iso	BGR	73	99	153	145	79	77	101	91
4	bo	mgb	BGR	79	152	130	93	76	85	78	97
5	dy	fru	BGR	74	115	121	105	79	74	67	74
6	dy	glu	BGR	67	119	162	150	120	51	51	57
7	dy	iso	BGR	89	123	180	144	75	65	81	84
8	dy	mgb	BGR	76	78	112	90	76	75	85	84
9	fk	fru	BGR	92	84	143	153	113	86	99	92
10	fk	glu	BGR	78	150	147	142	130	83	44	60
11	fk	iso	BGR	78	115	163	165	137	66	70	81
12	fk	mgb	BGR	89	118	166	141	92	79	84	85
13	ln	fru	BGR	74	91	123	104	91	90	88	90
14	ln	glu	BGR	73	103	150	135	141	99	57	71
15	ln	iso	BGR	80	103	119	112	103	92	71	86
16	ln	mgb	BGR	73	87	109	133	116	75	76	68
17	mj	fru	BGR	85	93	94	75	76	77	73	73
18	mj	glu	BGR	83	118	148	161	133	89	50	65
19	mj	iso	BGR	74	85	134	132	89	59	58	58
20	mj	mgb	BGR	78	82	122	86	93	73	83	87
21	mm	fru	BGR	77	95	131	119	94	98	101	94
22	mm	glu	BGR	63	105	159	160	176	197	134	127
23	mm	iso	BGR	81	94	118	121	88	69	70	84
24	mm	mgb	BGR	88	111	118	103	81	79	83	86
25	mt	fru	BGR	92	101	122	101	85	78	75	73
26	mt	glu	BGR	83	81	135	99	89	44	50	63
27	mt	iso	BGR	79	90	140	152	166	92	59	62
28	mt	mgb	BGR	87	92	149	137	83	64	76	87
29	sk	fru	BGR	92	111	136	101	120	111	111	94
30	sk	glu	BGR	89	117	153	133	146	153	155	99
31	sk	iso	BGR	90	135	178	148	113	69	77	87
32	sk	mgb	BGR	93	137	136	134	134	101	83	76

VITA

Julie Kay Collins

Candidate for the Degree of

Master of Science

Thesis: RESPONSE OF BLOOD GLUCOSE LEVELS TO VARIATIONS OF THE MEAL-ON-THE-GO BAR

Major Field: Food, Nutrition and Institution Administration

Biographical:

Personal Data: Born in Mangum, Oklahoma, August 29, 1965, the daughter of Stanley and Ella Davis; one brother, Jeff Davis, three sisters, Cindy Shero, Audrey Davis, and Peggy Davis; married to Joe Collins.

Education: Graduated from Wilburton High School, in May, 1983; received a Bachelor of Science in Arts and Sciences from Oklahoma State University in December, 1986.

Professional Experience: Graduate Research Assistant, Oklahoma State University, March 1987 - May 1988.

Professional Organizations: Institute of Food Technologist.

Awards: M.B. Seretean Scholarship, March 1988; Member of Omicron Nu (Honorary Home Economics Fraternity).