EFFECT OF FIBER ON SUCROSE ABSORPTION

By

JERI KATHERINE SMITH

Bachelor of Science in Home Economics

Oklahoma State University

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Thesis Approved:

Donna Payne-Boss
Thesis Adviser

Bernice Kopek

Robert D Morrison

Norman N Durham
Dean of Graduate College

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CHAPTER I

INTRODUCTION

Research from many countries suggests a need to change the eating patterns of most affluent nations. Though the view is controversial, high consumption of fats and refined carbohydrate and low consumption of fiber has been linked to increased heart disease, diabetes, varicose veins, and other diseases (Burkitt, Walker, and Painter, 1974). Burkitt et al. (1974) report that:

> . . . cereal fiber is necessary not only for the 'bulk' it provides in the intestine but also for its effect on the chemical and bacteriological processes that take place in the intestine. Evidence has been presented to show that its removal from the diet may, directly or indirectly, cause certain diseases that are becoming an increasing problem in western countries (p. 1073).

Considerable research has been conducted on fiber and its relationship to serum lipids and diverticular disease (Trowell, 1972; Eastwood, M., and Girdwood, R., 1968; Brodribb, A., 1977). Some research has appeared which uses serum glucose levels to determine the effect of dietary fiber on glucose absorption.

Spiller and Amen (1974, p. 1259) indicated that, "Too few investigators are involved in major research efforts aimed at elucidating the effects of fiber on physiological functions in man." They continued that, ". . . the need

for laboratory-controlled experiment is obvious." Kay (1977, p. 12) reported that, ". . . there is a need to investigate the effects of different classes of food fiber as eaten."

Because little information has been published on the effect of fiber on sucrose absorption and breath hydrogen levels, a study was designed to determine the effect which might occur.

Purpose of the Study

The purpose of the study was to determine effects of unprocessed wheat bran on sucrose absorption and breath hydrogen rise. Five subjects were given three different test meals each. Essentially, one test meal was sucrose in water, one was unprocessed wheat bran in water, and one was unprocessed wheat bran and sucrose in water (see Methods for further details).

Hypotheses

The following hypotheses guided the research effort. They were:

H_1: Consumption of 25 grams sucrose would result in no breath H_2 response.

H_2: Consumption of 30 grams unprocessed wheat bran would result in no breath H_2 response.

H_3: Consumption of 25 grams sucrose and 30 grams unprocessed wheat bran would result in a breath H_2 response.

Assumptions

Certain assumptions were made concerning the research effort. They were:

1. All participants were in good health.
2. All participants fasted for 12 hours before the tests.

Limitations

Limitations of the study were:

1. The research was limited by the size of the sample.
2. The research was limited by the sex of the participants, females only.
3. The research was limited by the type of fiber (unprocessed wheat bran) which was used.
4. The research was limited by the age of the subjects. All subjects were 22 through 25 years of age.

Definition of Terms

Definitions pertinent to the study were:

absorption: to take up or assimilate, specifically in the small intestine.

breath hydrogen (H_2): the hydrogen present in human breath.

breath H_2 response: breath H_2 execretion greater than 20 ppm (Caskey, 1976).

fiber: ". . . the remnants of vegetable cell walls which are not hydrolyzed by alimentary enzymes of man" (Trowell, 1973, p. 151).

gas chromatography: ". . . an analytical method of separation in which the substances to be analyzed are distributed between two phases" (Heftmann, 1967, p. 182).

sucrose: a disaccharide composed of a molecule of glucose linked to a molecule of fructose.

unprocessed wheat bran: the bran layer of the wheat kernel which has not undergone bleaching, drying, pressing or other processing.

CHAPTER II

REVIEW OF LITERATURE

Since 1970, public interest in the role of fiber in the diet increased sharply, coinciding with the numerous international research efforts concerning this dietary component. This chapter reviews the role and function of fiber in the diet as well as its relationship to disease. In addition, the techniques of gas chromatography and breath hydrogen analysis are briefly discussed.

Fiber

Though fiber was previously identified and described, it should be noted that there were variations in the composition and digestibility among the different types of vegetable fiber. In wheat bran for example, only one quarter of the estimated cell wall material was crude fiber and it had a digestibility which was much lower than that of other vegetables (Van Soest and McQueen, 1973). There were differences not only among the vegetable fibers, but within a group as well according to Eastwood, Fisher, Greenwood, and Hutchinson (1974):

> There are varying amounts of fiber in different varieties of wheat, and the composition of the fiber (cellulose, hemicelluloses, pectins and

> lignins) varies from layer to layer of the seed coats as well as among bran, germ and endosperm (p. 1029).

Each variety of commercial wheat bran would vary in its content of attached endosperm, and most likely in the amount and composition of the indigestible constituents.

The classic determination of the fiber content in foods was done by digesting the material with strong acid and strong alkali media (Robinson, 1972). The resultant fraction was the crude fiber of the food. New methods were developed which were more analytical but also had drawbacks. Southgate (1973, p. 131) reported ". . . in many respects these newer methods are of limited value in human nutrition, primarily because they were developed for nutritional studies with the ruminant." Further, he stated that ". . . crude fiber determination . . . using more refined methods tend to over-estimate the proportion of the plant cell wall that can be digested by man." Some cellulose was digested during passage through the intestinal tract (Southgate and Durnin, 1970).

The role of fiber itself was quite complex and would involve an interaction of the type of fiber consumed, the amount of fiber consumed, and the other dietary components consumed at the same time as the fiber. Leeds, Gassull, Metz and Jenkins (1975, p. 213) found ". . . addition of guar flour to a test meal increased mouth to caecum transit time by 120 - 125 percent as judged by the first appearance of hydrogen in breath." Individual response was critical

in the overall picture of the digestibility of fiber, as fiber was rarely consumed as a purified substance, except for research purposes (Kay, 1977).

Fiber and Disease

Extensive research was conducted on the relationship of fiber to disease, specifically diseases associated with a high fat, highly refined diet. Working in Africa, Burkitt, Walker and Painter (1974), noted that:

> Many diseases common in and characteristic of modern western civilization have been shown to be related to the amount of time necessary for the passage of intestinal content through the alimentary tract, and to the bulk and consistency of the stools. These factors have been shown to be greatly influenced by the fiber content of the diet and by the amount of cereal fiber in particular (p. 1068).

The diseases implicated included coronary artery disease, appendicitis, diverticular disease of the colon, gallbladder disease, varicose veins, deep vein thrombosis, hiatus hernia, hemorrhoids and tumors of the colon and rectum, and obesity. All were relatively rare until the early part of this century, suggesting a strong link with the refined carbohydrate foods and lack of fiber. Burkitt (1974, p. 1068) and his colleagues also found cereal fiber to be necessary ". . . not only for the 'bulk' it provides in the intestines but also for its effect on the chemical and bacteriological processes that take place in the intestine."

Brodribb (1977) used a high fiber diet over a period of three months to determine the effect on diverticular disease. There was greater relief of symptoms for those on

the high fiber diet than in the control group, and the effectiveness of the high fiber diet increased over three months. From this, he stated that:

> Patients should be warned that high-fibre diet takes several months to produce a maximum therapeutic response and they should be encouraged to persist with it even if it causes initial abdominal discomfort (p. 665).

Eastwood (1977) noted that:

> . . . it is possible to increase fecal bulk by the use of cereal bran. Undoubtedly in the treatment of diverticular disease, and constipation, the introduction of bran has been of great benefit (p. 2).

Further, he recommended an informal dietary regimen as follows:

> . . . take one handful of coarse bran per day with milk, sugar, and some fruit for the first week and thereafter two handfuls. In addition, the individual should take wholemeal bread, and fruits and vegetables such as apples, oranges and carrots (p. 2).

The relationship of fiber to lipid metabolism was investigated by many researchers. One general conclusion was that:

> Certain food fibers can bind bile acids and remove them via the feces, whereas normally they are absorbed in the lower gut. The continual loss of bile acids triggers a change in their relative concentration, and the system uses up cholesterol to synthesize more. Thus the cholesterol level is lowered, some scientists claim, and this in turn, is linked to the prevention of heart disease (Progress through Research, 1977, p. 2).

Eastwood and Girdwood (1968) found that the rate of degradation of cholesterol to bile salts was in part determined by the concentration of bile salts in the portal vein.

They also observed that ". . . fibrous tissue in vegetable matter can absorb bile salts" (p. 1171). They further concluded that the effect of different lignin preparations would vary since the adsorption rate increased with methylation.

Eastwood and Hamilton (1968) reported that bile salts and acids were maximally adsorbed when the acidic groupings on the fiber were unionized, such as in an acid medium or by methylation.

Forman, Garvin, Forestner and Taylor (1968) found that in one week, using an oral hydrophilic colloid, lower serum cholesterol values were obtained and remained lower throughout the experiment and the excretion of fecal bile acids increased more than 300 percent over the control period.

Shurpalekar, Doraiswamy, Sundaravalli, and Rao Narayana (1971, p. 555). working with an atherogenic diet and children, found that, "Inclusion of cellulose in the diet to the extent of 20 percent increased the bile acid excretion to 212.7 mg/day from a norm of 78.5 mg/day." They concluded that a high level of cellulose does show a beneficial effect in lowering serum cholesterol, even when given a hypercholesterolaemic diet.

Heaton and Pomare (1974) found a significant lowering of serum triglycerides in 14 subjects fed unprocessed wheat bran, though they did not find a significant lowering of serum cholesterol.

> Data has been produced to support a hypothesis that high consumption of natural starchy car-

> bohydrates, taken with their full complement of fiber, is protective against hyperlipidemia and IHD /Ischemic heart disease/. Experiments in animals and man may be interpreted to support a suggestion that dietary fiber decreases the reabsorption of bile salts, increases fecal excretion, and reduces hyperlipidemia (Trowell, 1972, p. 930).

Findings by other researchers support this notion. The Lancet (1975, p. 355) stated that "Clearly, the interrelation between fibre and lipid metabolism is complex, and more specific characterisation of vegetable dietary fibre and its constituents is necessary." Further research in the area was also indicated by Heaton and Pomare (1974, p. 50) who stated, "These preliminary findings indicate the need for more research into the properties of dietary fibre, and particularly into its metabolic effects."

Fiber and Glucose

Gassull, Goff, Haisman, Hockaday, Jenkins, Jones, Leeds and Wolever (1976) stated that the high incidence of diabetes in western culture can be correlated to a relative lack of fibre in the diet. Other researchers added to this hypothesis.

Eastwood (1977, p. 2) stated that, ". . . it is possible to influence the glucose tolerance test and dependence on oral hypoglycemic agents by increasing the fiber content of the diet." Jefferys (1974) found that bran improved glucose tolerance at 60, 90, and 120 minutes and that it also reduced the area under the curve. Furthermore, "The peripheral blood glucose values suggest that bran reduces the glucose absorption per unit . . ." (p. 12A).

Ricketts (1976, p. 2322), working with diabetic subjects found that ". . . fiber mix permitted the mean blood glucose to drop by 40 to 60 percent during a 15 to 90 minute period, and the mean serum insulin level was decreased during 30 to 120 minutes . . ." Several of his subjects were also able to reduce their insulin intakes. This correlates with Jefferys (1974, p. 12A) findings that ". . . the presence and the nature of indigestible carbohydrate in the diet can modify the metabolic response to digestible carbohydrate." Miranda and Horowitz (1977) reported that increasing dietary fiber may be useful in lowering plasma glucose for some diabetic patients.

Douglass (1975), working with the raw diet and insulin requirements, found that some subjects had their insulin requirements reduced using dietary management alone. Trowell (1973) reported to the Nutrition Society that small rodents on a high fiber diet did not become obese or develop diabetes as their counterparts on a low fiber diet did, suggesting that high fiber helped to moderate insulin levels.

Jenkins, Leeds, Wolevar, Goff, Alberti, Gassull, and Hockaday (1976, p. 172) suggested that ". . . addition of certain forms of dietary fibre to the diet of diabetics significantly decreases post-parandial hyperglycaemia and would be expected to improve the control of blood-glucose concentration." Their work concerned the use of guar and pectin as an addition to a control meal for non-insulin requiring diabetics. Their findings showed a significant decrease in

the rise of blood-glucose between 30 and 90 minutes and showed a significant decrease in insulin levels between 30 and 120 minutes.

Jenkins et al. (1976, p. 173) found that "Wheat bran added to a test meal of glucose syrup produced a significant though small decrease in the peripheral blood-glucose rise." They concluded that dietary fiber may prove useful as an addition to insulin treatment in other forms of diabetic therapy by facilitating blood-glucose homeostasis.

Jenkins, Leeds, Gassull, Cochet, and Alberti (1975, p. 22) found that addition of guar to a test meal does not result in malabsorption of glucose and a rise in breath hydrogen. Their conclusion was that the presence of some unabsorbable carbohydrate in the diet may reduce the rise of blood glucose and insulin which normally follows a carbohydrate containing meal.

Haber, Heaton, Murphy and Burroughs (1977, p. 681) testing the depletion and disruption of dietary fiber, found that "Juice evoked a substantially greater rise in serum-insulin than did apples" and that "Insulin release was apparently greater after juice and puree, even though the rise in plasma glucose was the same." This suggested that the fiber in the whole apple had a moderating effect on serum insulin and glucose levels. Gassull et al. (1976, p. 53P) suggested that the effects of blood glucose:

> . . . may be due to slow release of glucose from intra-luminal gels in the small intestine and that such unabsorbable carbohydrates warrant fur-

ther investigation especially as potential therapeutic agents in the treatment of diabetes."

Breath Hydrogen

Previous investigations indicated that pulmonary H_2 excretion could be used to detect carbohydrate malabsorption. The technique of measuring breath hydrogen was based on the findings that (a) H_2 is produced almost entirely in the colon when carbohydrate is fermented by colonic bacteria, and (b) respiratory H_2 excretion was an accurate indicator of colonic H_2 production (Bond and Levitt, 1975, p. 574). An increase in breath H_2 after ingestion of carbohydrate would occur only if a portion of the material ingested was not adsorbed and delivered to the colonic bacteria (Bond and Levitt, 1972, p. 1219). Several investigators measured hydrogen by thermal conductivity after chromatographic separation (Calloway, 1966; Calloway, Murphy and Bauer, 1969; Payne-Bose, Tsegaye, Morrison and Waller 1977).

Metz, Jenkins, Peters, Newman and Blendis (1975) found that breath hydrogen measurement has given a similar result to blood glucose rise in the estimation of hypolactasia and that the method could be easily adapted to field surveys in order to determine incidence of lactose malabsorption in a general population. A significant finding from Metz and his colleagues was that "Fifteen patients with a blood glucose rise of more than 20 mg/100 ml. had less than 4 p.p.m. rise in breath H_2 at two hours," (p. 1155). Metz and his col-

leagues also found that normal enzyme activity gave no significant breath H_2 rise.

Levitt and Donaldson (1970) found that in normal subjects, ingestion of glucose never resulted in an increase in breath H_2. Of the breath hydrogen technique, they stated that:

> This technique has advantages over the tolerance test in that: (1) It reflects the quantity of the sugar not absorbed and, thus, is not influenced by gastric emptying rate or intermediary glucose metabolism, and (2) it is sufficiently sensitive to detect malabsorption of as little as 5 to 10 gm of carbohydrate (p. 937).

Bond and Levitt (1977) noted the aforementioned advantages of the breath hydrogen test and also found it to be attractive in that it was less expensive than the collection and analysis of five or six blood samples required for a tolerance test. Bond and Levitt employed the technique to identify lactose malabsorbers and found it to be satisfactory (1976).

Dubowski (1974) found breath as a physiological specimen to have several advantages: it was rapid, simple, nontraumatic and frequently repeatable. The disadvantages he noted were the same as for all methods: possibility of sample contamination, and the need for subject cooperation. Payne-Bose, et al. (1977) found another advantage to the technique: the samples collected into impermeable bags could be analyzed for up to three days after collection with no significant change in H_2 concentration.

Calloway and Murphy (1968, p. 90) found the H_2 concentration of expired air to be modified under conditions in which emotionality appeared to be the dominant influence, rather than food and bacterial effects as could be anticipated. Stress apparently gave a rise in the breath H_2.

Levitt and Ingelfinder (1968) found H_2 to be produced whenever fermentable substrate was supplied to the enteric bacteria. The source could be carbohydrates not absorbed in the small intestine. H_2 production occurring in all subjects was almost completely dependent upon these ingested fermentable substrates. Levitt (1969, p. 126) stated that "The extremely low rate of H_2 production for subjects fasted 24 hours suggests that endogenous sources supply little fermentable substrate."

Calloway (1966, p. 387) found that there was no ". . . threshold level of breath hydrogen about which subjective responses are universally present or absent." Thus, there was no norm for a basal breath sample. Calloway in 1969 noted several advantages of the breath hydrogen test previously mentioned and postulated that the method was equally effective in detecting malabsorption of disaccharides other than lactose.

Chromatography

The subject of gas chromatography was thoroughly reviewed by Heftmann (1967). Semenza, Auricchio, and Rubino (1965) found reliable reproducibility of chromatographic

procedure and recommended a low flow rate for the carrier gas involved.

Breath analysis and its application for the clinical setting was a relatively new procedure, originally used on a limited scale for breath alcohol determination. Politzer, Dauty, and Laseter (1976, p. 1785) found that breath analysis by chromatographic separation carries ". . . considerable potential as a general diagnostic tool for the future."

CHAPTER III

METHODS AND PROCEDURE

The five subjects participating in this experiment were healthy caucasians between 22 and 25 years of age. All subjects were volunteers who were associated with the university as graduate students or in extension. None were diabetic, and none had used antibiotics for two weeks prior to the study. Also, none reported any recent history of gastrointestinal disturbance. Each subject gave informed consent (Appendix A) before participating in the study.

Test Meals

Three test meals were used which were:

S: 25 grams sucrose and 0.1 gram cinnamon in 250 milliliters water;

SB: 25 grams sucrose, 30 grams fiber[1] and 0.1 gram cinnamon in 250 milliliters water;

B: 30 grams fiber and 0.1 gram cinnamon in 250 milliliters water.

Test meals B and SB were prepared by heating in a microwave oven for three minutes. The heating of the test

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[1]Unprocessed wheat bran, Harrington's Hodgson Mill Brand, Hodgson Mill Enterprises, Inc., Gainsville, Mo. 65655.

meals and the addition of the cinnamon were done to increase the palatability of the test meals. A pretest conducted on one subject using 0.5 grams cinnamon in 150 milliliters plain tea produced no breath hydrogen response. Therefore, it was assumed that 0.1 gram cinnamon could be added to each diet to increase acceptance.

Test Procedure

Each subject was given a pretest which consisted of fasting for 12 hours, then coming to the laboratory to breathe into a bag. This procedure, done on Thursday the week prior to the Monday, Wednesday, Friday sequence, was conducted to familiarize each subject with the laboratory, the procedures, and to reduce any psychological effects due to apprehension.

Each subject was instructed to fast 12 hours prior to the test. The tests usually began at 8:00 a. m. and were administered on alternate days of the same week. Each test meal was consumed by each subject in random order (Table 1).

On the day of the first test, the technician briefly restated the test procedures and obtained a signed consent form as well as a completed questionnaire from each subject (Appendix A). During the test, the subjects were free to read or to study but not to engage in any activity which might lead to physical exertion.

The test began when the subject arrived at the laboratory after rising at least one hour beforehand to allow the

breath hydrogen to reach body equilibrium (Caskey, 1976). No food was allowed the morning of the test, but water, black decaffinated coffee and plain tea were allowed as desired. Each subject was instructed to inform the technician of any symptoms felt during the test such as headache, bloated feeling, and intestinal gas, and these were duly recorded.

TABLE I

SEQUENCE OF TEST MEALS

Subject Identification Number	Days		
	Monday	Wednesday	Friday
1	S	SB	B
2	SB	S	B
3	S	SB	B
4	B	S	SB
5	S	B	SB

S = sucrose test meal; B = bran test meal;
SB = sucrose and bran test meal.

Breath was sampled as was previously described by Caskey (1976). Each subject blew several breaths through two plastic cylinders, one containing barium hydroxide lime, used to remove carbon dioxide from the breath and one con-

taining anhydrous calcium sulfate, used to remove water from the breath. Once the subject had blown through the cylinders to allow for gas exchange in the column, the attached four liter, hydrogen gas diffusion proof bag was opened in order to receive expirations. When the subject had filled the bag approximately one-half full, it was clamped off and stored for analysis within a three-day period. The H_2 content of breath was measured using gas chromatographic analysis (Payne-Bose, Tsegaye, Morrison and Waller, 1977).

Analysis of Breath Samples

The breath hydrogen was analyzed using a Hewlett-Packard 5834-A gas chromatograph with thermal conductivity detector and automatic gas sampling valve. The carrier gas used was argon with a flow rate of 13 ml. per minute. The oven temperature was maintained at 50° C throughout the experiment and the thermal conductivity detector temperature was maintained at 165° C. A 5-A molecular sieve column, 6 feet long with 1/8" diameter was used in the analysis. The quantitative analysis was done using a calibration curve technique. Each sample was stored and analyzed within a three-day period after being filled. The breath gases from each bag were analyzed using the gas chromatograph and the hydrogen concentration for each sample was recorded in parts per million (ppm). The samples were analyzed in random order to eliminate any bias on the part of the technician.

Statistical Analysis

The data from the study were analyzed as a randomized block design in which each subject was considered as a block and each treatment as days (Steel and Torrie, 1960). Each subject served as her own control. The study was designed to show the effect of each diet on the subject and the differences among subjects.

CHAPTER IV

RESULTS AND DISCUSSION

Five subjects with normal carbohydrate tolerance were selected to test the effect of unprocessed wheat bran on sucrose absorption. The subjects were healthy females between 22 and 25 years of age. They were given three test meals in random order and the differences among diets and among individuals were analyzed. Breath H_2 excretion determinations were done along with each test meal. If subjects gave a breath H_2 response when unprocessed wheat bran and sucrose were consumed together, but not when the other two test meals were consumed, the implication would be that the unprocessed wheat bran causes some sucrose to be unabsorbed.

Because the factor of the human response was involved, the coefficient of variability (CV) between individuals was extremely high. Using the average of the three highest responses for each subject for each day, the CV was computed as follows:

$$CV = \frac{\sqrt{\frac{\text{error mean square}}{3}}}{\text{overall mean}} \cdot 100 = \frac{\sqrt{\frac{87.09}{3}}}{8.9333} \cdot 100 =$$

$$\frac{\sqrt{29.03}}{8.9333} \cdot 100 = \frac{5.3888}{8.9333} \cdot 100 = .603 \cdot 100 = 60\%$$

The subject with the highest responses was removed and the CF was computed to be 51 percent. Since this was not significantly lower, it was suggested that individual response was a key factor in the experimental error.

Diet Effect

Analysis of variance between the H_2 responses showed no significant difference among the diets. The calculated F value for the diet effect was .88869, which was less than the table value of F, 4.46 at the 0.05 significance level. Therefore, hypotheses 1 and 2 were accepted and hypothesis 3 was rejected. Figure 1 shows the average response of all subjects to each of the three test meals. The average response to the bran test meal was 11.533 ppm H_2; to the sucrose and bran test meal, 7.333 ppm H_2; and to the sucrose test meal, 7.933 ppm H_2. These differences were not statistically significant.

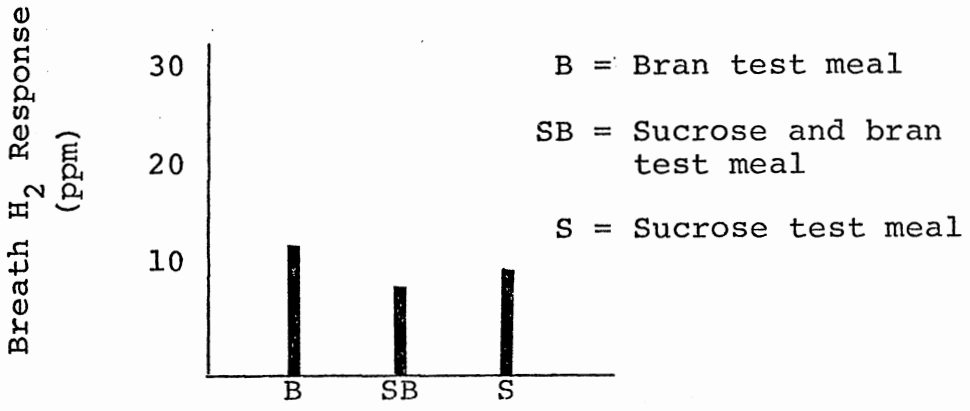

Figure 1. Average response to diet by subjects.

Subject Effect

Analysis of variance between the H_2 responses showed no significant difference among the subjects. The calculated F value for the subject effect was 2.37265, which was less than the table value of F, 3.84, at the 0.05 significance level. Therefore, it was accepted that there was no significant difference among subjects. Figure 2 shows the average response of each subject to all of the test meals. The average responses were as follows: #170, 10.777 ppm H_2; #172, 5.444 ppm H_2; #173, 5.555 ppm H_2; #174, 6.333 ppm H_2; #175, 16.555 ppm H_2. These differences were not statistically significant. The complete analysis of variance is shown in Appendix C.

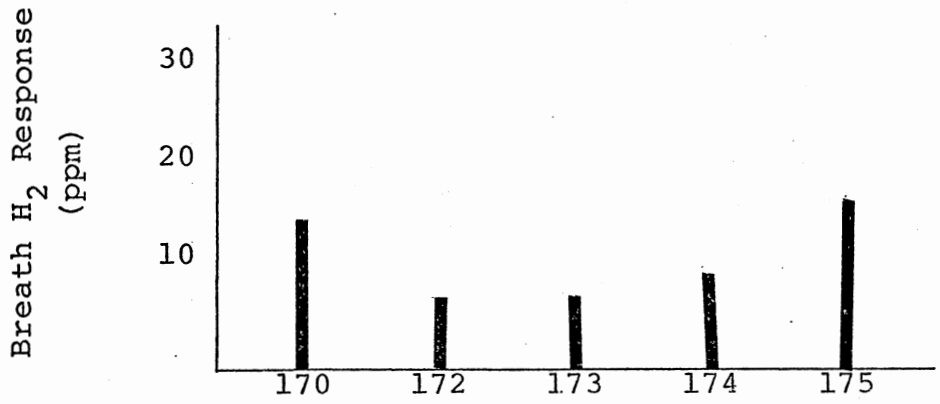

Figure 2. Average response to all diets by subject.

Disscussion

This study showed no difference in the breath hydrogen response to three test meals. This suggested that all subjects were indeed carbohydrate tolerant and that the ingested sucrose was fully absorbed. No response to the unprocessed wheat bran and sucrose test meal indicated that the bran did not interfere with the digestion and absorption of sucrose.

The breath hydrogen test was easy to administer and caused no discomfort to the subjects. Studies previously cited have used blood glucose levels to measure fiber effect on sucrose absorption but this can cause apprehension and discomfort to the subject and may result in an elevated breath hydrogen response if there is an emotional effect, (Calloway and Murphy, 1968).

CHAPTER V

SUMMARY

Breath hydrogen excretion was used to determine sucrose malabsorption in the presence of unprocessed wheat bran in five healthy females between the ages of 22 and 25. The test meals consisted of 30 grams of unprocessed wheat bran plus 0.1 gram cinnamon in 250 milliliters of water; 30 grams unprocessed wheat bran plus 25 grams sucrose plus 0.1 gram cinnamon in 250 milliliters water; and 25 grams sucrose plus 0.1 gram cinnamon in 250 milliliters of water. Statistical analysis showed no significant differences between the diets or among the subjects.

The study indicated a need for further research. Some topics which could be investigated are:

1. Test different dose levels of unprocessed wheat bran combined with different levels of sucrose.
2. Test other forms of fiber and of carbohydrate.
3. Analyze blood glucose levels as well as breath H_2 response in order to determine the accuracy of the breath hydrogen test for these test meals.
4. Use diabetic subjects and test serum glucose and insulin levels as an indicator of the effect of fiber on sucrose absorption.

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APPENDICES

APPENDIX A

STATEMENT OF INFORMED CONSENT

Research, Experimentation or Demonstration
Involving Human Subjects

I hereby acknowledge that I have been informed of the nature of the research for which I am to participate as part of the project, Fiber's Effect upon the Absorption of Sucrose.

Statement of Procedure:

The subject will arrive in the morning after having a good night of sleep and no food or drink (except water) since 8:00 p. m. the previous evening. Testing will start soon after the arrival in the laboratory. The subject should become familiar with the surroundings and feel relaxed and comfortable in the lab and lounge area. Please feel free to ask the technician any questions that may concern you.

There will be three days of testing in this particular series. Each day will involve collecting breath samples every 15 minutes for 180 minutes, and the collection of four blood samples every 30 minutes for 90 minutes, both occurring simultaneously.

Discomforts:

There is no risk or discomfort, with the exception of the finger stick, involved in either of the tests. Both the Breath Hydrogen Test and the blood test are completely safe. The test meals are composed of foods which can be

purchased from your local market, i.e. bran and simple table sugar.

I have been given an opportunity to ask and receive answers to any questions concerning procedures. I have been informed that I am free to withdraw my consent and to discontinue participation at any time. Furthermore, I agree that there has been no attempt, either written or oral, to get me to waive any of my legal rights or to hold any person or other entity blameless except as provided by law. I hereby give my informed consent to participate in the research study.

Date:_____ Signature_____

QUESTIONNAIRE

Name: _____

ID # _____

Date: _____

Please answer the following questions to the best of your ability.

Have you eaten any food or had any drink with the exception of water in the last 12 hours: _____

What time did you get out of bed this morning? _____

Are you a diabetic? If yes, what medication do you take? _____

Have you been ill during the last seven days? _____

Have you taken any of the following drugs in the last ten days?

antibiotics: _____

sulfa drugs: _____

others: _____

Do you smoke? _____

Are you taking birth control pills? _____

APPENDIX B

Subject: 170

Diet: Fiber Plus Sucrose

Date of Test: 12-5-77 M

Time	H_2 Peak Area	H_2 ppm	Blood Glucose mg./100 ml.
000	221	9	66
015	161	6	--
030	114	4	88
045	68	3	--
060	53	2	66
075	0	0	--
090	49	2	69
105	0	0	--
120	173	7	--
135	255	10	--
150	242	9	--
165	221	9	--
180	196	8	--

Subject: 170

Diet: Fiber

Date of Test: 12-7-77 W

Time	H_2 Peak Area	H_2 ppm	Blood Glucose mg./100 ml.
000	142	6	83
015	243	9	--
030	174	7	78
045	285	11	--
060	106	4	86
075	263	10	--
090	204	8	85
105	254	10	--
120	128	5	--
135	163	6	--
150	188	7	--
165	231	9	--
180	268	10	--

Subject: 170

Diet: Sucrose

Date of Test: 12-9-77 F

Time	H_2 Peak Area	H_2 ppm	Blood Glucose mg./100 ml..
000	425	16	67
015	422	16	--
030	260	10	105
045	292	11	--
060	130	9	89
075	281	11	--
090	231	9	89
105	161	6	--
120	160	6	--
135	136	5	--
150	223	8	--
165	232	9	--
180	192	7	--

Subject: 172

Diet: Fiber Plus Sucrose

Date of Test: 1-9-78 M

Time	H_2 Peak Area	H_2 ppm	Blood Glucose mg./100 ml.
000	0	0	84
015	54	2	--
030	0	0	73
045	0	0	--
060	102	4	64
075	136	5	--
090	67	3	81
105	75	3	--
120	87	3	--
135	67	3	--
150	158	6	--
165	88	4	--
180	147	6	--

Subject: 172

Diet: Sucrose

Date of Test: 1-11-78 W

Time	H_2 Peak Area	H_2 ppm	Blood Glucose mg./100 ml.
000	242	10	82
015	199	8	--
030	102	4	115
045	137	5	--
060	72	3	85
075	106	4	--
090	59	2	lost data
105	65	3	--
120	50	2	--
135	148	6	--
150	78	3	--
165	0	0	--
180	0	0	--

Subject: 172

Diet: Fiber

Date of Test: 1-13-78 F

Time	H_2 Peak Area	H_2 ppm	Blood Glucose mg./100 ml.
000	0	0	97
015	133	5	--
030	0	0	103
045	140	6	--
060	0	0	70
075	0	0	--
090	59	2	92
105	0	0	--
120	0	0	--
135	0	0	--
150	0	0	--
165	0	0	--
180	0	0	--

Subject: 173

Diet: Sucrose

Date of Test: 1-23-78 M

Time	H_2 Peak Area	H_2 ppm	Blood Glucose mg./100 ml.
000	0	0	76
015	0	0	--
030	0	0	96
045	0	0	--
060	0	0	86
075	0	0	--
090	0	0	75
105	0	0	--
120	0	0	--
135	0	0	--
150	0	0	--
165	0	0	--
180	0	0	--

Subject: 173

Diet: Fiber Plus Sucrose

Date of Test: 1-25-78 W

Time	H_2 Peak Area	H_2 ppm	Blood Glucose mg./100 ml.
000	0	0	111
015	70	3	--
030	32	1	93
045	71	3	--
060	0	0	90
075	0	0	--
090	79	3	96
105	0	0	--
120	176	7	--
135	318	13	--
150	71	3	--
165	149	6	--
180	72	3	--

Subject: 173

Diet: Fiber

Date of Test: 1-27-78 F

Time	H_2 Peak Area	H_2 ppm	Blood Glucose mg./100 ml.
000	0	0	95
015	502	20	--
030	180	7	102
045	0	0	--
060	39	2	103
075	0	0	--
090	0	0	104
105	0	0	--
120	0	0	--
135	0	0	--
150	0	0	--
165	0	0	--
180	0	0	--

Subject: 174

Diet: Fiber

Date of Test: 1-2-78 M

Time	H_2 Peak Area	H_2 ppm	Blood Glucose mg./100 ml.
000	0	0	96
015	163	6	--
030	129	5	109
045	267	11	--
060	280	11	90
075	88	4	--
090	154	6	95
105	149	6	--
120	86	3	--
135	166	7	--
150	69	3	--
165	96	4	--
180	87	3	--

Subject: 174

Diet: Sucrose

Date of Test: 1-4-78 W

Time	H_2 Peak Area	H_2 ppm	Blood Glucose mg./100 ml.
000	79	3	78
015	0	0	--
030	0	0	145
045	153	6	--
060	0	0	104
075	85	3	--
090	0	0	84
105	0	0	--
120	62	2	--
135	0	0	--
150	68	3	--
165	0	0	--
180	0	0	--

Subject: 174

Diet: Fiber Plus Sucrose

Date of Test: 1-6-78 F

Time	H_2 Peak Area	H_2 ppm	Blood Glucose mg./100 ml.
000	0	0	65
015	0	0	--
030	0	0	104
045	0	0	--
060	0	0	89
075	137	5	--
090	207	8	69
105	154	6	--
120	176	7	--
135	198	8	--
150	102	4	--
165	151	6	--
180	116	5	--

Subject: 175

Diet: Sucrose

Date of Test: 1-30-78 M

Time	H_2 Peak Area	H_2 ppm	Blood Glucose mg./100 ml.
000	294	12	103
015	499	20	--
030	283	11	144
045	431	17	--
060	370	15	106
075	330	13	--
090	294	12	102
105	495	20	--
120	350	14	--
135	399	16	--
150	335	13	--
165	276	11	--
180	330	13	--

Subject: 175

Diet: Fiber

Date of Test: 2-1-78 W

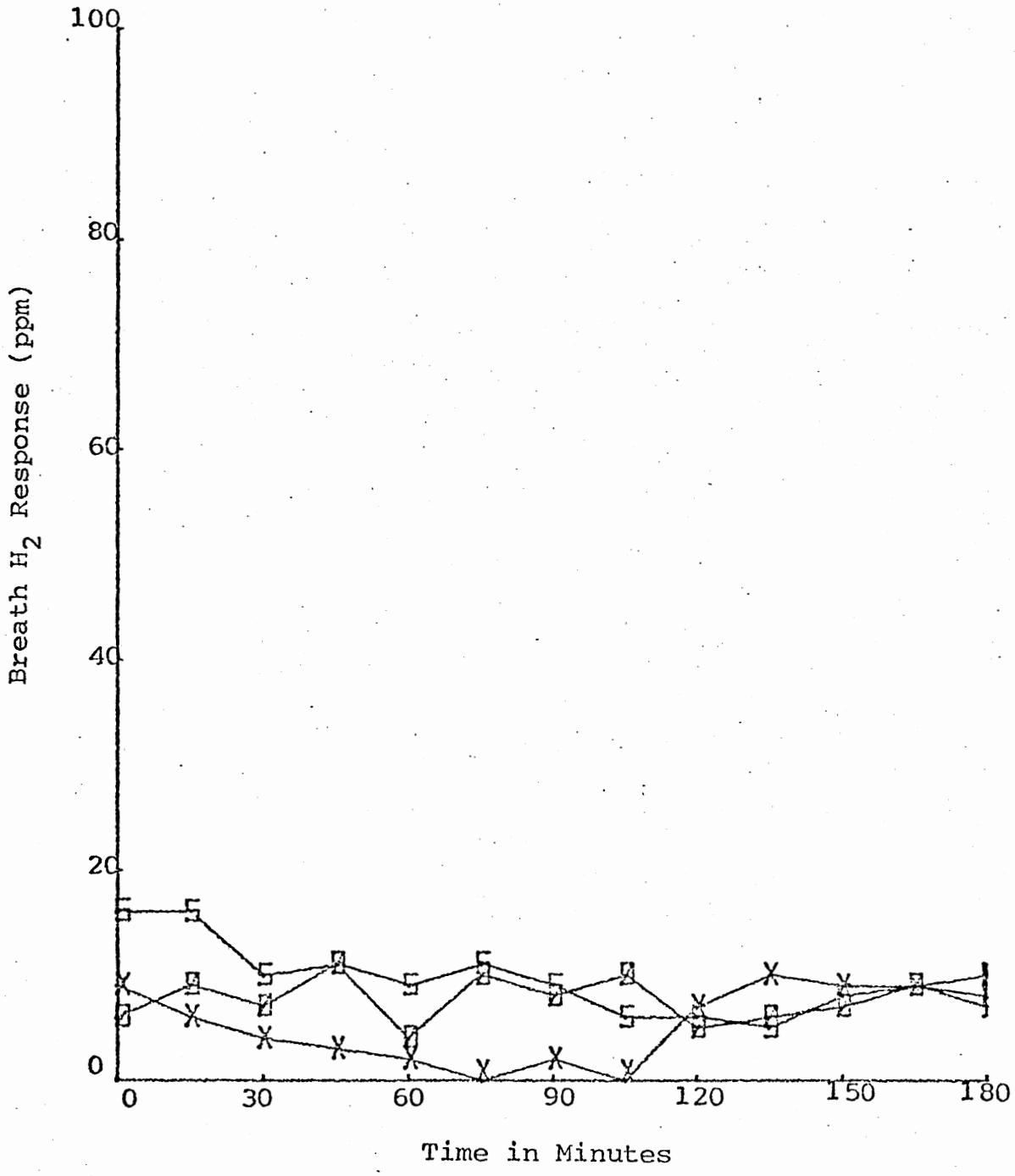
Time	H_2 Peak Area	H_2 ppm	Blood Glucose mg./100 ml.
000	428	17	117
015	591	24	--
030	446	18	146
045	463	18	--
060	421	17	134
075	651	26	--
090	671	27	116
105	658	26	--
120	471	19	--
135	517	21	--
150	658	26	--
165	805	32	--
180	578	23	--

Subject: 175

Diet: Fiber Plus Sucrose

Date of Test: 2-3-78 F

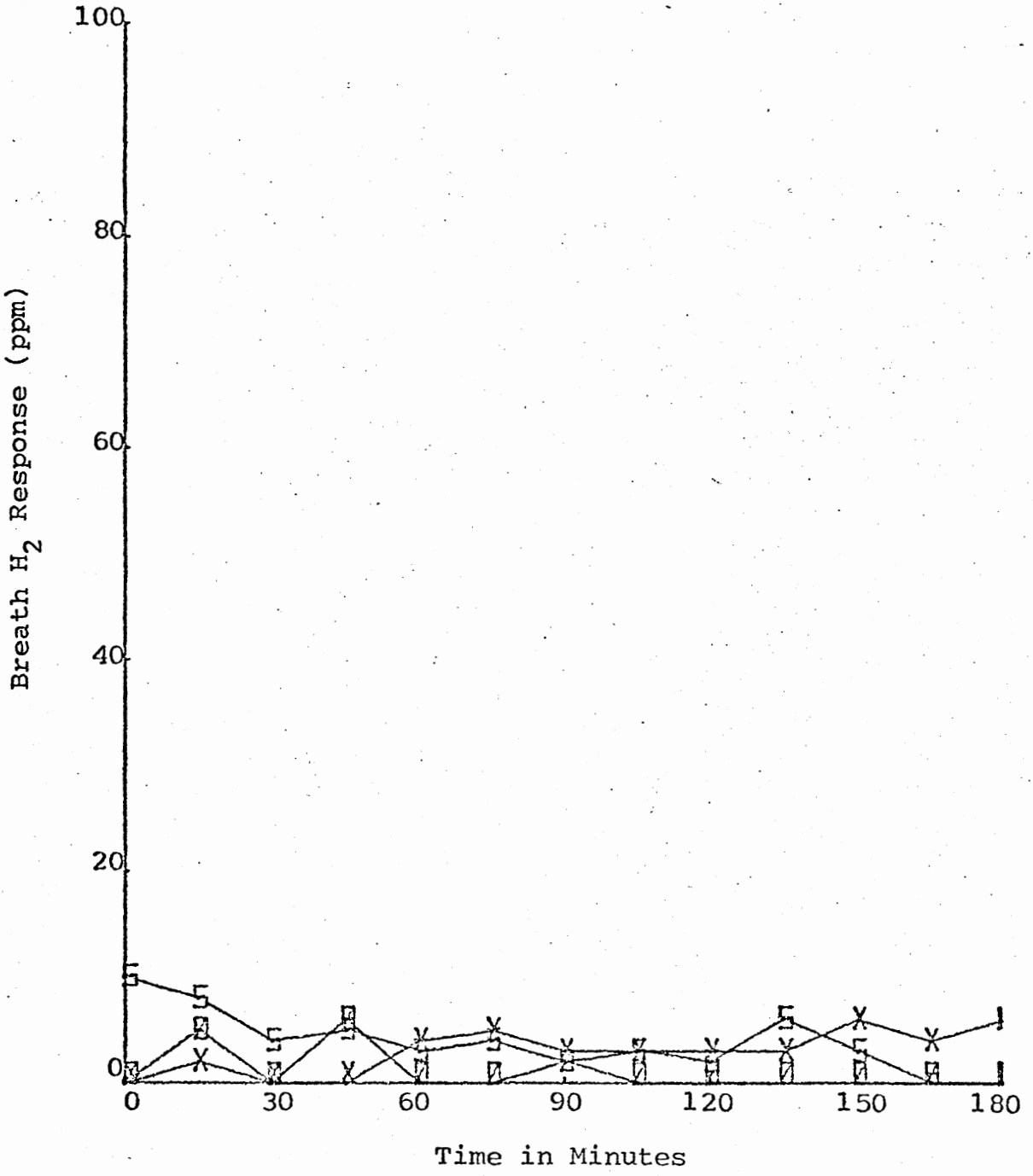
Time	H_2 Peak Area	H_2 ppm	Blood Glucose mg./100 ml.
000	0	0	95
015	58	2	--
030	55	2	136
045	62	2	--
060	63	3	107
075	58	2	--
090	54	2	83
105	58	2	--
120	0	0	--
135	65	3	--
150	135	5	--
165	178	7	--
180	239	10	--



Subject 170

X = Sucrose and Bran
O = Bran
S = Sucrose

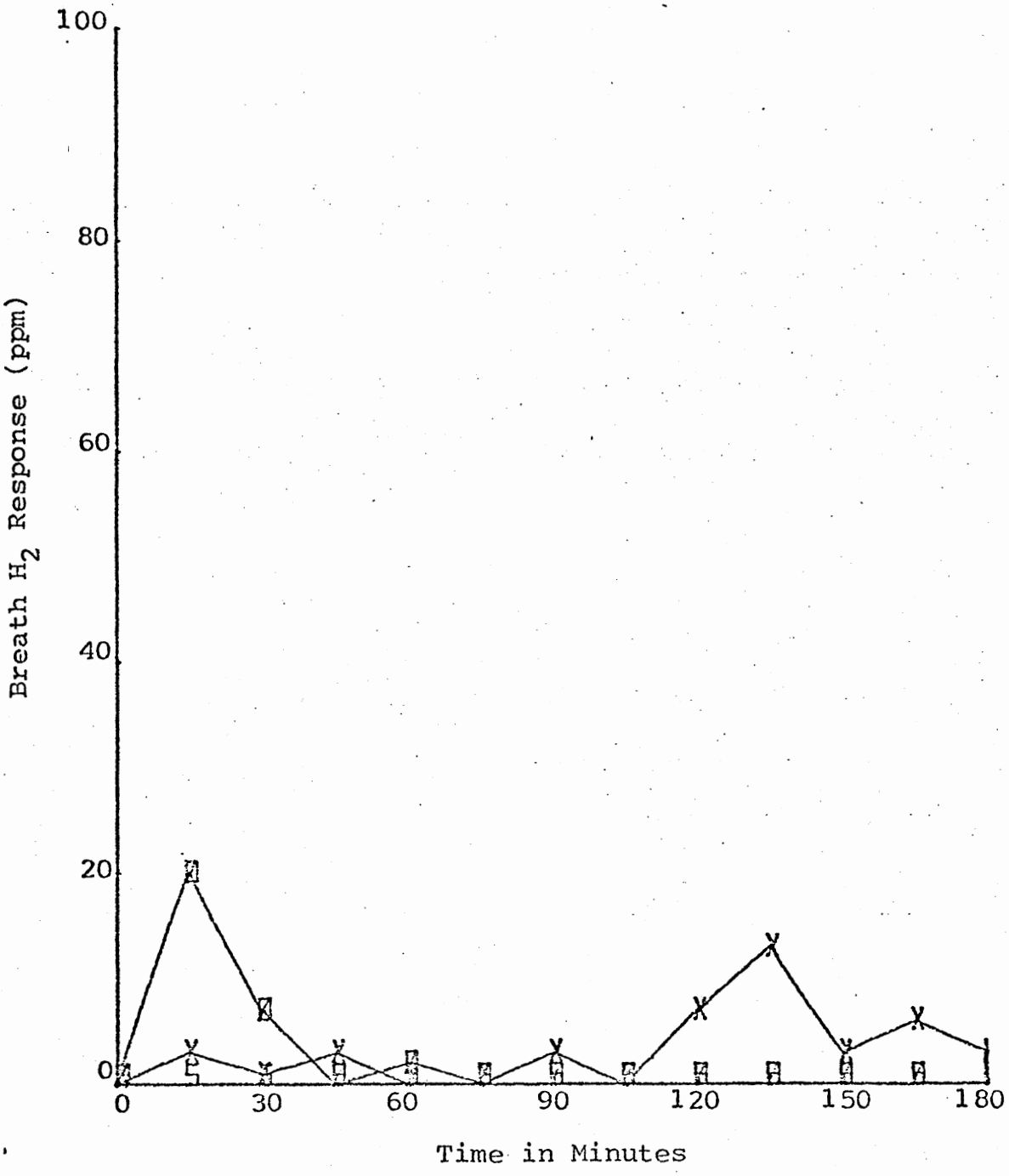
Graph B-1. Individual Response to Diets.



Subject 172

X = Sucrose and Bran
O = Bran
S = Sucrose

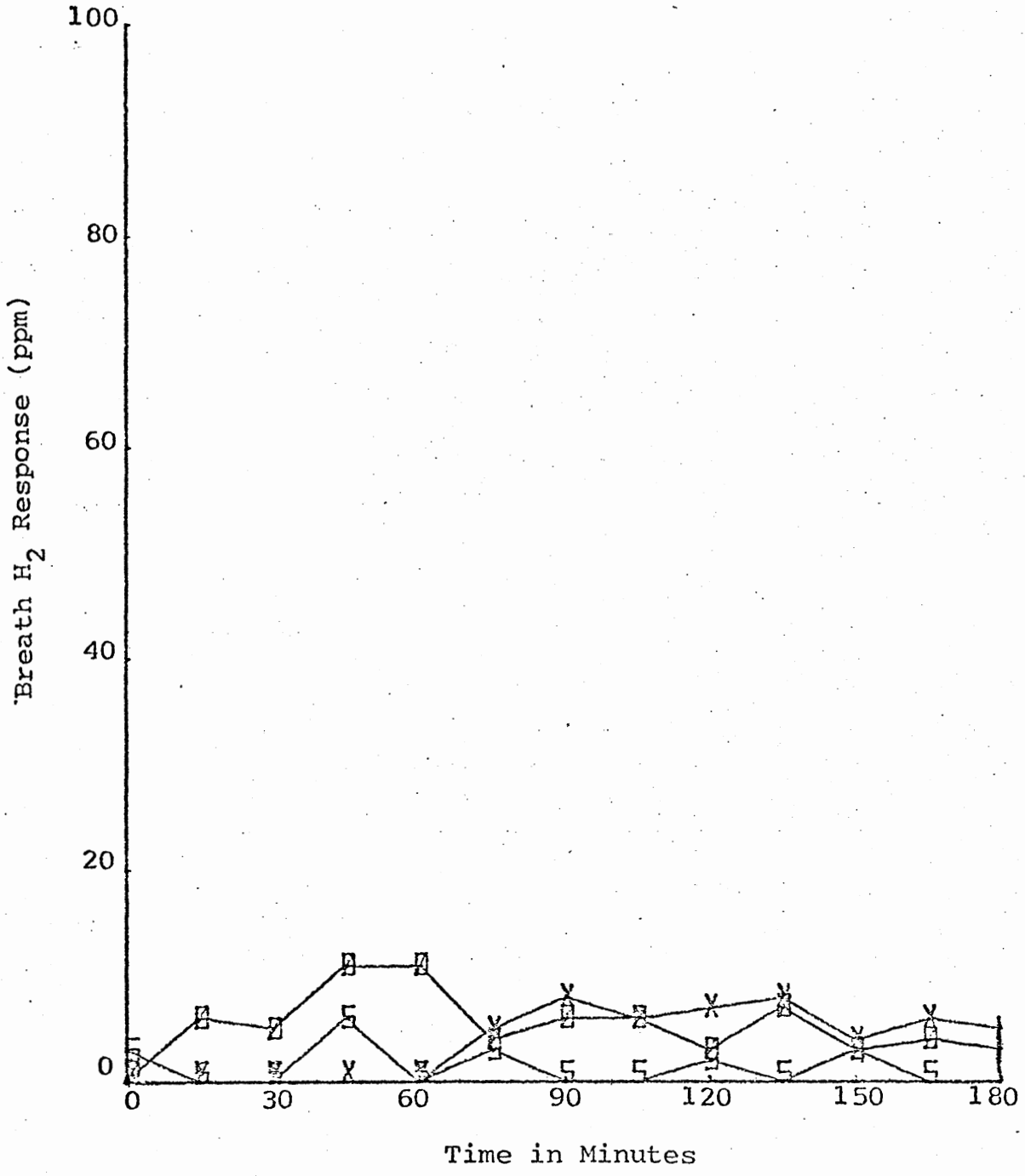
Graph B-2. Individual Response to Diets.



Subject 173

X = Sucrose and Bran
O = Bran
S = Sucrose

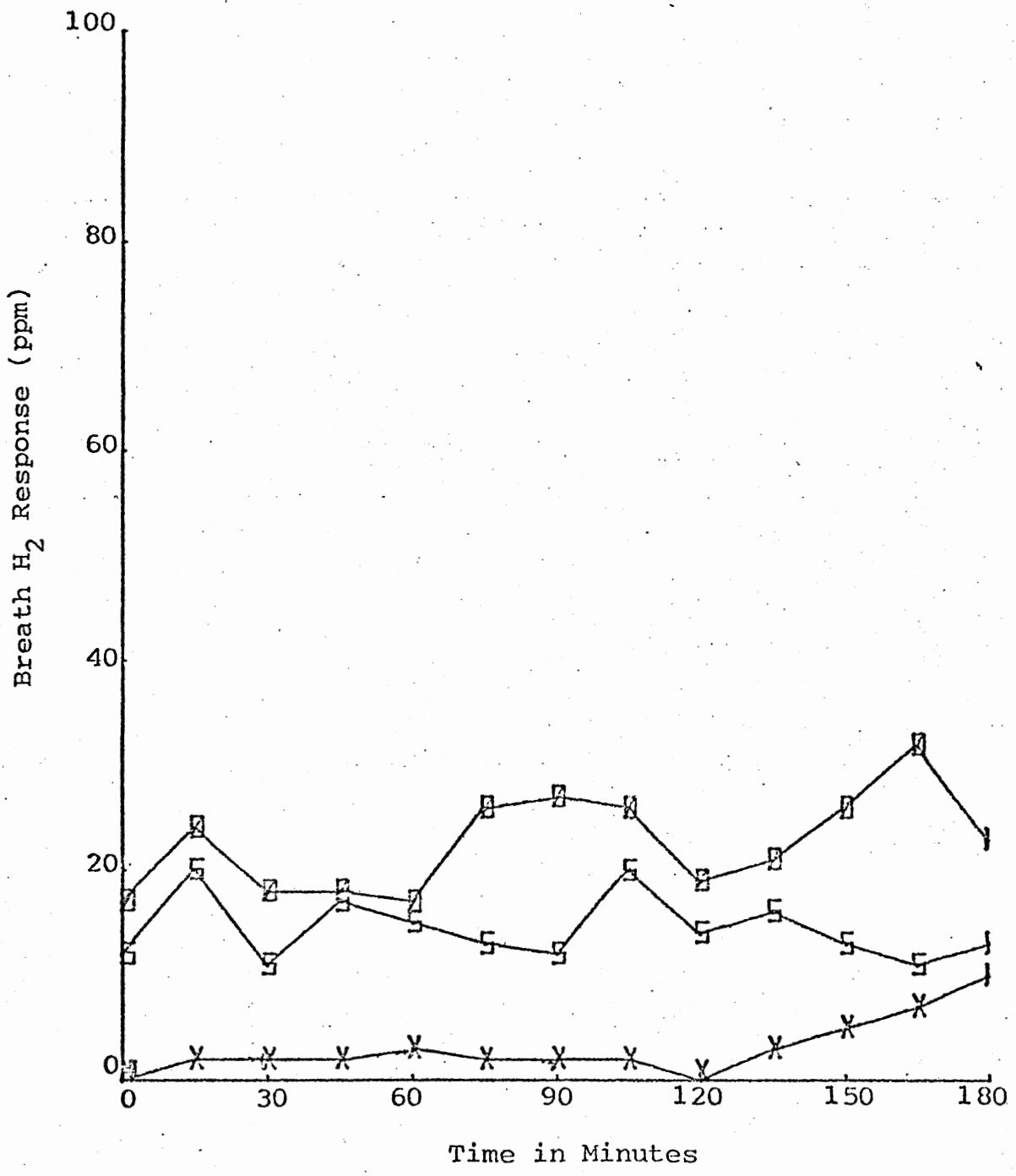
Graph B-3. Individual Response to Diets.



Subject 174

X = Sucrose and Bran
O = Bran
S = Sucrose

Graph B-4. Individual Response to Diets.



Subject 175

X = Sucrose and Bran
O = Bran
S = Sucrose

Graph B-5. Individual Response to Diets.

APPENDIX C

ANALYSIS OF VARIANCE FOR VARIABLE H_2 PPM

Mean 8.93333333

Source	DF	Sum of Squares	Mean Square	F	OSL*
Subject	4	826.57778	206.644444	2.37	0.139
Diet	2	154.80000	77.400000	0.89	0.549
Subj/Diet (Error Mean Sq.)	8	696.75556	87.094444		

* Probability > F

VITA

Jeri Katherine Smith

Candidate for the Degree of

Master of Science

Thesis: EFFECT OF FIBER ON SUCROSE ABSORPTION

Major Field: Food, Nutrition, Institution Administration

Biographical:

Personal Data: Born in Des Moines, Iowa, August 31, 1954, the daughter of Mrs. Amelia G. Smith.

Education: Graduated from Memorial Senior High School, Tulsa, Oklahoma, in May 1972; attended Oral Roberts University, The University of Iowa and received a Bachelor of Science degree in Home Economics from Oklahoma State University in December 1976; completed requirements for the Master of Science degree at Oklahoma State University in July 1978.

Professional Experience: Graduate Teaching Assistant Graduate Research Assistant in Food, Nutrition, Institution Administration at Oklahoma State University 1977-1978.