IMPACT OF CORN BRAN ON ENERGY AND SELECTED NUTRIENT INTAKE OF HEALTHY ADULTS

By

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CHAPTER I

INTRODUCTION

Fiber, once considered of little consequence, has now come to the forefront of current issues. "Its nature has been misunderstood and its important role in maintaining normal gastrointestinal function has not been appreciated" (Burkitt, Walker, and Painter, 1974, p. 1070). Nutritionists have, for the most part, ignored fiber which, being largely indigestible, does not break down into absorbable nutrients. Instead, it is excreted directly as part of the feces (Burkitt, Walker, and Painter, 1974; Anonymous, 1979). Fiber is now being thought of as an essential nutrient, since it has potential preventive and corrective capabilities (Burkitt, 1973).

The amount needed to safeguard against different diseases is still not known (Burkitt and Trowell, 1975). Fiber is being added to foods commercially and at home in an attempt to increase the intake of fiber and lessen the chances of developing certain diseases associated with modern western civilization (Burkitt, 1973; Burkitt, Walker, and Painter, 1974).

According to Burkitt (1973, p. 274), "A number of diseases of major importance are characteristic of modern western civilization." The list includes: appendicitis, diverticular disease of the colon, cancer of the colon, ulcerative colitis, varicose veins, deep vein thrombosis, hemorrhoids, gall stones, ischemic heart disease, obesity,

diabetes, and hiatus hernia (Burkitt, 1973; Eastwood, 1974; Leveille, 1976). In countries where the traditional way of life is still observed, there is a low, if any, incidence of these diseases.

With affluence, there is a deviation from the traditional way of life with concurrent adoption of western customs. The western diet calls for brown flour to be put aside for white, increase in both fat and sugar consumption, and an overall decrease in the consumption of fiber-containing products; whole grain cereals, legumes, potatoes, etc. (Burkitt, 1973). This century alone has seen a significant decline in the consumption of fiber, 20 percent in the area of fruits and vegetables, and as much as 50 percent in the area of cereals and grains (Scala, 1974). Acceptance of western customs results in a higher frequency of diseases mentioned previously (Painter and Burkitt, 1971; Burkitt, 1973). Burkitt (1973) does not suggest that a fiber deficiency is the sole causative factor in the incidence of the diseases discussed, but that it may be a contributing factor.

It was demonstrated that dietary fiber may, in fact, interfere directly with fat and cholesterol absorption in studies where rolled oats, 140 g and 125 g, respectively, were ingested daily in products, replacing the usual intake of cereal and bread products (DeGroot, Luyken, and Pikaar, 1963; Judd and Truswell, 1981). Studies done by Kirby, Anderson, Sieling, Rees, Chen, Miller and Kay (1981) and Scala (1974) also support this finding.

Both epidemiological data and clinical studies point to dietary fiber as being a preventive and corrective measure for diverticular disease (Burkitt, Walker, and Painter, 1974; Leveille, 1976; Trowell, 1976). In a study where 25 g of unabsorbable carbohydrate, guar gum,

was added to the diet of diebetics, their mean urinary glucose excretion was reduced by 40 to 50 percent (Jenkins, Hockaday, Howarth, Apling, Wolever, Leeds, Bacon and Dilawari,1977).

Besides being linked to certain diseases, dietary fiber also affects other nutrients. Its ability to act as a cation exchange resin may have some undesirable effects (Kelsay, 1978). Different studies indicate a decrease in absorption of minerals, such as: iron, calcium, magnesium, potassium, and zinc as bran levels increase (Monte, 1981; Widdowson and McCance, 1942; Bjorn-Rasmussen, 1974; Reinhold, Ismail-Beigi, Faradji, 1975). There are conflicting views as to the role fiber plays in mineral absorption (Heaton and Pomare, 1974; Persson, Raby, Fonns-Bech and Jensen, 1975).

Both Burkitt (1973) and Scala (1974) suggest the reincorporation of fiber into food as a means of increasing daily consumption of fiber. The questions of how much fiber and what kind have not been answered; however, new foods are becoming increasingly available which contain all types of gums, pectins, and hemicelluloses (Tsai, Elias, Kelley, Lin and Rabson, 1976).

In determining an individual's dietary intake, several methods are available which include: 24 hour recall, diet history, interview, and diet record. The different methods do not yield comparable results when calculated for specific nutrients; hence, they cannot be used interchangeably (Young, Chalmers, Church, Clayton, Tucker, Werts and Foster, 1952a; Young, Hagen, Tucker, and Foster, 1952b). Trulson (1954), in assessing dietary study methods, thought it was very difficult to determine which method gives the correct food intake. After completion of a study, one researcher felt that if only a diet history

had been used, serious errors would have occurred. When a small number of participants is involved in a research program, quantitative records of actual food intake should be used (Huenemann and Turner, 1942). There is need for further research in this area.

Purpose

The purpose of this study was to determine the effects of adding corn bran (20 g NDF) to experimental food systems in self-selected diets of healthy adults. Specific objectives were as follows:

1. To determine the effects of corn bran (20 g NDF) on the mean intake of energy (calories), macronutrients, and micronutrients of healthy adults according to sex and three dietary periods.
2. To determine if corn bran (20 g NDF) will affect bowel habits of healthy adults according to three dietary periods.

Assumptions and Limitations

The assumptions made for this study were as follows:

1. Food systems with added 20 g corn fiber were actually consumed.
2. Complete and accurate food records were kept by participants as instructed.

The limitations accepted in this study include the following:

1. Only fine grain corn bran, obtained from A. F. Staley Manufacturing Company in Decatur, Illinois, was used in the food systems developed.

2. Food systems with added fiber were not always the same for all participants because an exchange list was available and participants' preferences were considered.
3. The participants in this study were limited to volunteers (students, faculty, and staff) at Oklahoma State University.

Definition of Terms

Dietary Fiber is the constituents of plant tissue that are not broken down by digestive enzymes in the human digestive tract. It consists mainly of unavailable carbohydrate, such as celluloses, pectic substances, hemicelluloses, gums, and mucilages. The noncarbohydrate substances which are also included in dietary fiber consist of lignin primarily, protein, complex unavailable lipids, and trace elements (Leveille, 1976; Southgate, 1977; Van Soest and Robertson, 1977; Van Soest, 1978; Anonymous, 1979).

Crude Fiber is the residue of plant food which remains after treatment with a solvent, hot acid, and then hot alkali. Crude fiber is composed primarily of lignin and cellulose since hemicellulose, pectin, and other components are lost during the extraction (Scala, 1974; Trowell, 1976; Anonymous, 1979).

Unavailable Carbohydrate refers to all plant polysaccharides impervious to digestion by the secretion of the human gastrointestinal tract (Southgate, 1975; Spiller and Amen, 1975).

Cellulose is the major component found in the cell wall of plants. Cellulose is made up of D-glucose units jointed by β 1-4 glucosidic

linkages. Even though it is insoluble in water, it does bind water in the gastrointestinal tract (Colmey, 1978; Huang et al., 1978; Anderson and Chen, 1979).

Lignin is the primary non-carbohydrate fraction in the plant cell wall. It is hydrophobic with a constipating effect, resistant to microbial degradation and absorbs bile acids. It consists of complex polymers of substituted phenyl propane units of various alcohols (Van Soest and McQueen, 1973; Eastwood, 1974; Huang, Gopalakriskna, and Nichols, 1978).

Pectin consists of polymeric galacturonic acid, arabinose, and galactose. It is very hydrophilic, can bind cations and organic materials such as bile acids, and can also form gels (Huang, Gopalakriskna, and Nichols, 1978; Anderson and Chen, 1979).

Hemicellulose is a complex carbohydrate that constitutes the secondary plant cell wall thickening, and has a xylose "back bone". It is largely extractable with alkali. Being hydrophilic, it has a water-holding capacity along with an ion-binding capacity (Van Soest and McQueen, 1973; Huang, Gopalakriskna, and Nichols, 1978; Van Soest, 1978; Anderson and Chen, 1979).

Neutral Detergent Fiber (NDF) is an organic residue which results after treatment with hot neutral detergent solution. NDF provides a measure of total cell wall, which includes lignin, cellulose, and hemicellulose (Southgate, 1975, 1977; Van Soest and Robertson, 1977).

Acid Detergent Fiber (ADF) is an organic residue which results after treatment with boiling acid-containing detergent. This preparation mainly represents crude lignin and cellulose fractions of plants (Southgate, 1975, 1977; Van Soest and Robertson, 1977).

Mucilages are polysaccharide components that are extractable with water, possess water binding properties (Spiller and Amen, 1975), and form gels in the small intestine (Anderson and Chen, 1979).

Gums consist of branched polymers of glucuronic and galacturonic acids with side branches of neutral sugars such as xylose, arabinose, and galactose (Windholz, 1976). They are soluble in water and form gels in the small intestine (Anderson and Chen, 1979).

Dietary Record is a "Detailed, quantitative listing of all foods consumed by an individual over a given period" (Chalmers, Clayton, Gates, Tucker, Wertz, Young and Foster, 1952, p. 711).

Period I refers to the first seven days of the experimental period in which subjects consumed food ad libitum without the addition of experimental food systems.

Period II refers to the subsequent 21 days following Period I in which subjects consumed food incorporating the experimental food systems, or with the addition of the experimental food system containing 20 g corn fiber.

Period III refers to the subsequent 14 days following Period II in which subjects consumed food incorporating food systems similar to the experimental food systems but without the added corn fiber.

Experimental Food Systems are food products developed for this study containing 0.3-9.0 NDF corn fiber per unit or serving. Forty items comprised an exchange list from which researchers prepared menus considering subjects' preferences, providing 20 g NDF corn fiber per day.

CHAPTER II

REVIEW OF LITERATURE

Current literature points to fiber as a significant nutrient. Previously, it was regarded as being unimportant since fiber provided little nutritive value while protein, fat and carbohydrate were extensively investigated. Epidemiological studies conducted by Burkitt demonstrated a possible causal relationship between fiber and certain diseases, which triggered much research in this area (Anonymous, 1979).

Terminology and Analysis of Fiber

Fiber is an all inclusive term for types of carbohydrate which yield support to the cell walls of plants and also provide protection for individual plant cells (Mayer, 1975). Quite often the term "fiber" is incorrectly used and misunderstood. Controversy still remains among researchers concerning the terminology and methodology to be used in the assessment of the fiber content of foods. Current problems faced in defining fiber and its chemical structure were identified by Van Soest and McQueen (1973) as being:

1. Conflicting concepts of what constitutes fiber.
2. The definition of lignin, cellulose and hemicellulose.
3. Achieving separation of lignin from interfering matter.

4. The isolation of indigestible fiber and its relation to the true fiber of food.

5. The failure of hemicellulose, cellulose and lignin to be chemically similar in different plant materials (p. 123).

Crude fiber and dietary fiber are the two terms used to denote the existence of fiber in food. Developed in 1806 by Einhof (Mendeloff, 1975), the crude fiber methodology and term were widely accepted, resulting in its extensive use for calculating the fiber content in foods. Crude fiber denotes the end product, residue, of plant food which is left after extraction with acid and alkali (Trowell, 1976).

"Approximate" and "unreliable" are the terms Southgate (1975) uses to describe the estimation of cellulose and lignin in food by the crude fiber method. On the average, the crude fiber method recovers only 20 percent of the hemicellulose, 10 to 50 percent of the lignin and 50 to 80 percent of the cellulose which greatly underestimates the fiber content in foods (Heller and Hackler, 1978). As little as one-fifth to one-half of the total dietary fiber found in food may be represented by the crude fiber values, making it of little use (Kelsay, 1978). After the sequential extraction process, only lignin and cellulose remain (Anonymous, 1979). Hemicellulose is removed during the extraction process by alkali and is therefore not present, or marginally so, in the residue which remains. Because of this, cereals which are comprised mostly of hemicellulose are shown to be insignificant sources of fiber, which is not the case (Mongeau and Brassard, 1979). A higher percentage of fiber is digested in the analysis procedure than would be in the human gastrointestinal system, making it of questionable use (Colmey, 1978).

Trowell in 1972 coined the term "dietary fiber" which unlike the term crude fiber, does not denote a method or procedure but according to Van Soest and Robertson (1977, p. 17) represents the "fiber in the form in which it is actually eaten in prepared food." Dietary fiber is defined as ". . . including all the components of a food that are not broken down by enzymes in the human digestive tract to produce small molecular compounds which are then absorbed into the bloodstream" (Anonymous, 1979, p. 35). Dietary fiber includes hemicelluloses, pectic substances, gums, mucilages, as well as the lignin and cellulose (Anonymous, 1979). Table I demonstrates the difference between crude fiber and dietary fiber values for a specific set of food products.

The fiber content in a food is measured by the residue remaining in the feces. The amount of undigested fiber may vary from person to person, depending on their biological make-up, making it difficult to analytically measure and possibly providing inaccurate results (Colmey, 1978). Since the percentage of fiber undigested by the gastrointestinal (GI) secretions varies among subjects, Colmey (1978) suggests the use of an analytical procedure such as the Neutral Detergent Fiber (NDF) method or the Acid Detergent Fiber (ADF) method as a means of defining dietary fiber. For the present, dietary fiber is the accepted term even though controversy still exists concerning the methodology used to calculate its content in food.

Dietary fiber is not a single substance but is a group of substances (Burkitt and Trowell, 1975). The different fiber components: cellulose, hemicellulose, lignin, pectin, gums and mucilages vary in their phsysiological functions and must be addressed when studying fiber. Fiber

TABLE I

A COMPARISON OF CRUDE FIBER AND DIETARY FIBER IN CERTAIN FOODS[a]

Food	Crude fiber g/100 g.	Dietary fiber g/100 g.
Breads and Cereals		
White bread	0.2	2.72
Whole wheat bread	1.6	8.50
All bran cereal	7.8	26.70
Cornflakes	0.7	11.00
Puffed wheat	2.0	15.41
Puffed wheat/sugar coated	0.9	6.08
Vegetables		
Broccoli tops, boiled	1.5	4.10
Lettuce, raw	0.6	1.53
Carrots, boiled	1.0	3.70
Peas, canned	2.3	6.28
Sweet corn, cooked	0.7	4.74
Fruits		
Apples, without skin	0.6	1.42
Peaches, with skin	0.6	2.28
Strawberries, raw	1.3	2.12
Nuts		
Brazil	3.1	7.73
Peanuts	1.9	9.30
Peanut butter	1.9	7.55

[a]Crude fiber data from USDA Handbook 8, Composition of Foods. Dietary fiber data from David Southgate, Medical Research Council, Cambridge, England.

Source: Anonymous, 1979, p. 36.

composition differs according to the food source and must be calculated by means of an analytical procedure (Anonymous, 1979). Since the crude fiber method is difficult to perform, expensive and time consuming, it is sometimes replaced by newer procedures (Belo and De Luman, 1981). Presently, fiber content has not been defined for all foods and available indexes are usually in terms of crude fiber values.

Van Soest and Wine (1967) developed the neutral detergent fiber (NDF) method for determining fiber content as a result of studying the use of detergents in both acid and neutral solutions while determining the fiber content in animal feeds. Plant tissue is extracted using boiling neutral detergent solutions resulting in a residue of lignin, cellulose, and hemicellulose. Isolation of the entire plant cell wall matrix is the major purpose of the NDF method (Van Soest and Robertson, 1977). The American Association of Cereal Chemists (AACC) adopted the NDF method in 1978 as the official method of fiber content determination (Belo and De Luman, 1981).

The Acid Detergent Fiber (ADF) method represents crude lignin and cellulose only, since the hemicellulose fraction of plants is extracted out. To calculate cellulose, the lignin is subtracted from the ADF value. Hemicellulose is calculated by subtracting the ADF value from the NDF value (Van Soest and McQueen, 1973). The residue is obtained after reflux for one hour in a water solution of two percent cetyltrimethyl ammonium bromide and N sulphuric acid (Van Soest and McQueen, 1973). The main value of the ADF method lies in its ability to estimate digestibility (Van Soest and Robertson, 1977). The ADF method is used officially by the Association of Official Analytical Chemists (AOAC) (Southgate, 1977).

Both procedures measure for insoluble substances thereby excluding most of the water soluble polysaccharides such as pectic substances. Hence, ADF and NDF methods, which are increasingly used for dietary fiber analysis underestimate the level of pectic substances (Belo and De Luman 1981).

Anderson and Clydesdale (1980a) took existing fractionation methods and refined them in order to develop the methodology needed to analyze and fractionate the bipolymers of dietary fiber. The total content of dietary fiber is better realized with the method since cold and hot water soluble constituents are measured. Values obtained using this methodology are in agreement with those values reported in literature.

The methodology was then used to fractionate and analyze the components of dietary fiber in corn bran. Table II portrays the dietary fiber constituents of corn bran and wheat bran.

The amount of neutral sugars in hemicellulose and cellulose fractions is very similar for both the corn and wheat bran. While they are similar in certain aspects they are also different in others as seen in the lignin values. Results of this nature suggest that each foodstuff will contain its own unique proportion of the constituents of dietary fiber (Anderson and Clydesdale, 1980b).

Anderson and Clydesdale (1980b) report that:

> Knowledge of the composition of these constituents is essential to predict the physiochemical properties of the dietary fiber which will ultimately determine its use as a possible nutritional therapeutic agent, food supplement, and/or functional ingredient of a food (p. 761).

Since fiber varies in its composition and properties, it is not possible to describe its characteristics using a single value (Van Soest,

TABLE II

PROFILE OF THE DIETARY FIBER CONSTITUENTS OF CORN BRAN AND WHEAT BRAN[a]

Fraction		Foodstuff[d] Wheat bran[e]	Corn bran[a]
Cold water	N[b]	0.79 ± 0.09	Tr
	A[c]	0.13 ± 0.01	0.07 + 0.01
Hot water	N	Tr	Tr
	A	0.06 ± 0.02	0.03 ± 0.01
Hemicellulose	N	25.14 ± 1.00	29.24 ± 1.11
	A	3.31 ± 0.40	5.25 ± 0.14
Cellulose	N	9.84 ± 0.75	12.34 ± 0.64
	A	1.98 ± 0.09	2.96 ± 0.09
Lignin		2.87 ± 0.21	0.23 ± 0.03
Dietary fiber[f]		44.12	50.12

[a]Anderson and Clydesdale, 1980b, p. 761.

[b]N = Neutral sugar fraction.

[c]A = Acidic sugar fraction.

[d]Foodstuff = values expressed as averages of four determinations (mean percent composition) ± standard deviation on a percent dry weight basis.

[e]Wheat bran = Values from Anderson and Clydesdale (1980a).

[f]Dietary fiber = Values obtained by summing the averages of the other constituents in the table.

1978). The major component found in the cell wall is cellulose (Colmey, 1978). Hemicellulose is part of the secondary wall thickening (Van Soest and McQueen, 1973), and thus named because of its intimate relationship to cellulose (Anderson and Chen, 1979). Cellulose is not water soluble and its main physiological action, which occurs in the gastrointestinal tract, is to bind water (Colmey, 1978). Hemicellulose and pectin with their hydrophilic capacity are most efficacious in increasing fecal weight (Huang et al., 1978) as compared to cellulose, which also increases stool weight, but to a lesser degree (Eastwood, 1974). Lignin has an ion-binding capacity as reported by Van Soest and McQueen (1973).

Like hemicellulose, lignin is also part of the secondary wall thickening. Being hydrophobic it has a constipating effect. It is the main noncarbohydrate fraction in the plant cell wall (Eastwood, 1974) and unlike hemicellulose, is not absorbed or digested in the colon, being resistant to microbial degradation (Van Soest and McQueen, 1973).

Both lignin and pectin have the ability to absorb bile acids (Eastwood, 1974; Anderson and Chen, 1979). According to Huang et al (1978), pectin has hypocholesterolemic properties. Pectin, along with gums and mucilages, having high affinities for water, swell in the presence of water and form gels in the small intestine (Anderson and Chen, 1979). Gums, "sticky substance extruded at the site of injury" (Anderson and Chen, 1979, p. 347) functions to repair the injured areas of a plant. Food industries incorporate certain gums into given products since they function in the capacity of emulsifiers, thickeners and stabilizers. Mucilages are the major storage polysaccharides of the plant (Anderson and Chen, 1979). Some digestibility occurs due to the bacterial enzymes in the GI tract. Pectin is almost entirely digested with

less than five percent recovered in the stool 56 to 87 percent of hemicellulose is digested; recovery of cellulose is around 40 percent (Anderson and Chen, 1979), with lignin recovery in the stool being most abundant (Huang et al., 1978).

Cutin along with lignin, protein and mineral constituents represents the major noncarbohydrate portion of the plant cell wall (Van Soest, 1978). Cutin is found in the peel and on the surface of fruits and vegetables as a waxy substance which protects the surface of plant tissues. It is resistant to strong oxidation (Van Soest, 1978).

Dietary Fiber and Disease Relationship

Dietary fiber has been classified in relation to its physiological related claims which consist of definite value, probable value and possible value. The definite value of fiber is in relieving constipation, while the probable value is in the treatment of diverticular disease of the colon. The possible value relates to the reduction of serum cholesterol levels and prevention of certain diseases such as cardiovascular disease, hemorrhoids, varicose veins, cancer of the colon, diabetes, appendicitis, obesity, gallstones, phlebitis, dental caries, irritable bowel, ulcerative-colitis and harmful effects of some toxic substances (Anonymous, 1979).

Most of the current interest in fiber and its possible causal relationship to certain diseases was sparked by epidemiological studies, the majority of which come from developing countries in Africa (Trowell, 1972; Burkitt, 1973). Burkitt, a British medical researcher and surgeon visited five continents in all making comparisons of the available

epidemiological evidence. Burkitt found that following the adoption of a Western style of living, diet included, the emergence and frequency of diseases was relatively constant for all five continents studied. Based on his research, Burkitt suggested that there are four stages which lead to the Westernization of diets resulting in certain diseases (Burkitt and Trowell, 1975). The first stage consists of the primitive diet which is mainly the natural unprocessed starches and plant foods; prevalence of diseases associated with Western civilization are uncommon. In the second stage, the Westernization of diet begins among the upper class and with it, obesity and diabetes become a common problem. Moderate Westernization of diets occurs in the third stage resulting in constipation, hemorrhoids, varicose veins and appendicitis. During the fourth stage, the Westernization of diets is advanced with diverticular disease, hiatus hernia, ischemic heart disease and colon-rectal cancer becoming widespread occurrences (Burkitt et al., 1974). In Table III, the prevalence of certain diseases in the United States population and the African population are summarized: "the prevalence of these diseases in populations of developing countries appears to relate to the extent of their departure from traditional patterns of life" (Burkitt, 1973, p. 275). The reduction of high fiber-containing foods during the Westernization process results in the rise of Western diseases according to Burkitt (1973).

This century has seen a significant decline in the consumption of fiber. Scala reports that between 1900 and 1970, the per capita use of whole wheat flour and cereals decreased by more than 60 pounds. Intake of fruits and vegetables in 1940 was 250 pounds per capita as compared to less than 80 pounds in 1970; at the same time, processed fruits and

TABLE III

PREVALENCE OF CERTAIN DISEASES[a]

Condition	In the United States	In Africa
Ischemic heart disease	Responsible for a third of all deaths	Virtually unknown. Incidence just beginning to increase slowly in large cities.
Appendicitis	The most frequent of abdominal emergencies	Virtually unknown in rural areas. Incidence starting to rise in more westernized communities
Diverticular disease	The most common disease of the colon.	Almost unknown
Gallstones	Present in some 10% of the adult population.	Exceedingly rare.
Varicose veins	Present in over 10% of the adult population.	Present in probably 0.1% of those living in a traditional manner. Increasing with adoption of western customs.
Deep vein thrombosis and resultant pulmonary embolism	These make hospital life increasingly hazardous.	Very rare.
Hiatus hernia	Demonstrable in nearly half the population over the age of 50 years.	Almost unknown.
Hemorrhoids	" " " " " "	Rare or very rare according to degree of westernization.
Cancer of the colon and rectum	Second only to lung cancer as a cause of death from neoplasms.	Rare
Obesity	Nearly half the adult population is markedly overweight.	Rare amongst those living wholly on traditional diets. Becomes common with urbanization and adoption of western foods.

[a] Burkitt et al., 1974, p. 71

vegetables increased from 65 pounds to almost 110 pounds per capita resulting in a net loss of 125 pounds per capita. Overall, the consumption of fiber from fruits and vegetables has declined by about 20 percent and fiber from cereals and grains has decreased markedly--50 percent in this century (Scala, 1974). Fiber consumption was decreased further when new milling practices were introduced between 1850 and 1890. Previously the amount of fiber content of white flour was estimated to be between 0.2 percent and 0.5 percent but in 1860 it declined to 0.1 percent and below. War time rationing in 1939 provided wheat flour of 85 percent extraction (0.3 g crude fiber/100 g) at which time, diverticular disease mortality rates began to decline. With the end of the war, white bread went back on the market in 1953 and death rates from diverticular disease rose. The same is true for ischemic heart disease (Trowell, 1972).

Certain types of dietary fiber produce a laxative effect. It is the pectin, hemicellulose and cellulose in foods which give it this characteristic. Bran is used to treat constipation and abnormal bowel activity (Painter, Almeida and Colebourne, 1972). Fiber binds water to itself, thereby increasing the water content of the feces producing bulkier, softer stools resulting in faster transit time and reduction in straining during defecation (Anonymous, 1979). According to Monte (1981, p. 78) the "laxative effect of bran was caused, primarily by the mechanical stimulus of distention due to the presence of large amounts of residue in the colon and enhanced by the water holding capacity of the bipolymers involved."

Diverticular disease is the outpouching of the intestinal wall. Diverticulitis results when the diverticula or pouches become filled with fecal matter resulting in infection (Scala, 1974; Mayer, 1975; Leveille, 1976). A rarity in 1900, diverticular disease, in the span of only 70 years, has become the most common disorder of the colon in Western countries (Painter and Burkitt, 1971).

At one time the low residue diet was used to treat diverticular disease with the idea in mind that less irritation to the bowel would enable healing to take place. Now the high fiber diet is being utilized and with good results (Brodribb and Humphreys, 1976). Painter et al.(1972) recommends bran in the treatment of constipation, diverticular disease, and other colonic disorders. For each gram of fiber incorporated into the diet, stool weight is increased by about 15 grams (Scala, 1974). Normal bowel habit was restored when two grams of cereal fiber (unprocessed bran) was given to constipated patients on a daily basis (Burkitt, 1973).

Both epidemiological data and clinical studies add support to the fiber deficiency theory as to the causation of diverticular disease (Trowell, 1976). The disorder develops because of the presence of a relatively small hard and dry feces in the intestine which increases pressure within the colon. When fiber is added to the diet it binds some of the available water, increasing the stool weight and creating a softer stool. This lessens the pressure within the colon and decreases transit time (Leveille, 1976). Soft stools are quickly passed with less strain; development of diverticulum is not favored (Painter and Burkitt, 1971).

In a study done by Bell, Emken, Klevay and Sandstead (1981), involving seven subjects, 25 to 26 grams of dietary fiber (soft whole wheat bran, corn bran, soybean hulls, hard red spring wheat fiber) was incorporated into the diet during four experimental periods. The experimental diet was well accepted and the average daily wet stool weight and the number of bowel movements per week increased when corn bran, soybean hulls and hard red spring bran was consumed. Soft whole wheat bran did not affect the number of defecations.

Diverticular disease is related to the following disorders: varicose veins, hiatus hernia and appendicitis (Latto, Wilkinson and Gilmore, 1973). In a study done using 110 patients with diverticular disease, 73 percent also had trouble with varicose veins (Latto et al., 1973). "Straining which is characteristic of diverticular patients causes undue pressure in the venous system of the large intestine and legs. This increases the development of hemorrhoids and varicose veins" (Scala, 1974, p. 35). Burkitt (1977) cites the intra-abdominal pressures transmitted down the veins of the leg as part of the etiology of varicose veins. With undue intra-abdominal pressure placed on the hemorrhoid vein, dilation may occur encouraging the development of hiatus hernia. As dietary fiber is added to the diet, there is some relief from hemorrhoids and varicose veins (Scala, 1974).

Dietary fiber, specific types, have been shown to alter cholesterol levels in the body. In one study, 21 male volunteers received 140 grams of rolled oats instead of the normal bread in their diet. Cholesterol levels dropped from 250 to 239 mg. per 100 ml. after only seven days of the experimental diet. Cholesterol levels reached 223 mg. per 100 ml.

within three weeks time, but when participants were returned to the control diet, serum cholesterol levels rose to a mean value of 246 mg. per 100 ml. after only two weeks (DeGroot, Luyken and Pikaar, 1963). Oat-bran is a cereal which contains an abundance of water soluble fiber (Kirby et al., 1981). Pectin and guar gum are both water soluble fibers which demonstrate distinct hypocholesterolemic effects (Judd and Truswell, 1981; Anderson and Chen, 1979).

In another study done by Kirby et al (1981), 100 g of oat bran was administered by way of muffins and hot cereals to eight men in a metabolic unit. Each 100 g preparation consisted of 26.4 g of plant fiber, 14.8 g of it being water soluble fiber. Serum cholesterol levels were reduced when oat bran was incorporated into the diet. Wheat bran and cellulose had little influence on cholesterol levels in studies conducted using rats (Anderson and Chen, 1979). There was a definite hypocholesterolemic effect when pectin and guar gum were fed to the rats. Dietary fiber varies in its biological action dependent on the type involved (Tsai, Elias, Kelley, Lin, Rabson, 1976; Judd and Truswell, 1981).

Cholesterol is the primary precursor of salts and bile acids. The excretion of bile acids is the mechanism by which cholesterol is removed from the body. Certain fractions of fiber incorporated into the diet may increase bile acid excretion (Anonymous, 1979) with concurrent reduction of bile acid reabsorption (Burkitt, 1973). The presence of dietary fiber may also lessen the absorption of ingested cholesterol. Burkitt (1973) suggests that a diet depleted of fiber may be one important factor, among others, which contributes to the development of ischemic heart disease. Changes in cholesterol metabolism due to alterations in dietary fiber intake may influence gallstone formation (Burkitt, 1973).

As to the possible relationship between dietary fiber and cancer of the colon, Burkitt postulated that diets depleted of fiber prolong the time the stool remains in contact with the intestinal mucosa and might favor carcinogenesis. With this in mind, the following mechanisms were suggested as a means to reduce colon cancer by dietary fiber (Huang et al., 1978):

1. Fiber decreases intestinal transit time, hence exposure to fecal carcinogens is reduced.
2. Fiber influences bile acid metabolism, hence less potential carcinogens are produced from bile acids.
3. Fiber, because of its ability to bind water, sterols, bile acids and fat, may act to dilute potential carcinogens.
4. Fiber may alter the flora in the intestine thereby decreasing the bacterial degradation of bile acids.

"Dietary fibers modify glucose absorption and may be of clinical usefulness in the prevention and treatment of adult-onset diabetes mellitus, hypoglycemia, and obesity" (Spiller and Kay, 1979, p. 2103). When fiber is ingested with carbohydrate (CHO), the rise in blood glucose levels and insulin concentrations are significantly lower as compared to a diet deficient in fiber.

In one experiment, whole apples, apple puree and apple juice were compared to determine the influence they had on satiety, plasma glucose and serum insulin changes. The whole apple produced the most satiety and demonstrated a smaller rise in plasma glucose. The apple puree tested out in the middle with the apple juice producing the

least amount of satiety and having the greatest rise in plasma glucose levels (Anderson and Chen, 1979).

Twenty-five grams of unabsorbable carbohydrate, guar gum, added to the diet of diabetics decreased their mean urinary glucose excretion by 40 to 50 percent. Results may have been due to the gel-forming type of fiber used in the experiment (Jenkin et al., 1977). According to Anderson and Chen (1979) any possible long term effects of fiber intake on glucose tolerance of healthy individuals has not been well established. Albrink (1978) hypothesized that a diet low in fiber, high in carbohydrate, especially simple sugars might cause resistance to insulin and trigger obesity by excessive stimulation of the insulin response mechanism.

Obesity is more prevalent in Western countries than elsewhere and may be a result of an increasing degree of dietary carbohydrate being consumed in refined form, thereby resulting in the reduction of fiber (Van Itallie, 1978). Attention has been called to three physiological obstacles to energy intake provided by dietary fiber (Heaton, 1973):

1. It displaces available nutrients.
2. By demanding chewing, it slows intake and induces satiety.
3. It reduces the absorptive efficiency of the intestine (p. 1419).

It has also been suggested by Heaton (1973) that refined products, white flour and sugar for example, are likely to promote excess energy intake since they are quickly ingested and absorbed efficiently. More research is needed to determine if a diet high in fiber is a deterrent to obesity.

Some work has been done associating a low intake of dietary fiber to dental caries. As of yet, nothing has been established (Bing, 1976).

Dietary Methods

Several methods are available for use in determining an individuals dietary intake which include: diet history, interview, 24-hour recall and the diet record. The selection of dietary method should be dependent upon the proposed study itself, with the many factors taken into consideration.

There are problems associated with every dietary method. Mojonnier and Hall (1968) report that direct measurement of food intake is feasible only for small groups. Food diaries may cause the participant to change his normal eating habits while accuracy of general histories is dependent on memory. Even though 24-hour recall histories may be more objective than general histories, they suffer because only one day is measured.

Dietary methods cannot be used interchangeably since they do not yield comparable results (Young et al., 1952a; Young et al., 1952b). It is difficult to say which method provides the most accurate information concerning food intake (Trulson, 1954). Huenemann and Turner (1942) believe that quantitative records of actual food intake should be used when subject number is limited. For the sake of accuracy, seven consecutive days or 20 consecutive meals is the shortest length feasible for the dietary record (Chalmers et al., 1952).

Relationship of Dietary Fiber to Energy and Nutrient Intake

The composition of the Western diet is compared with the Trappist monk, Yeminite and the Bedouin diets in Table IV (Groen, 1973). The Western diet as compared to the other three groups has a higher fat intake and a lower carbohydrate intake. Total CHO intake for the Western diet is 250 g, 115 of it being of monosaccharide and disaccharide origin whereas the Trappist monk, Yeminite and Bedouin intakes of CHO are comprised mainly of starch. Fiber intake is lowest in the Western diet. It is now considered that the incorporation of bread in the diet, replacing saturated fat, functions to lower serum cholesterol levels similar to replacement by polyunsaturated fat. There is an increased excretion of neutral steroids and bile acids which accompanies the lowering of serum cholesterol levels (Groen, 1973).

The incorporation of fiber in the diet influences caloric and nutrient intake as shown in the following studies. Nine girls (16-18 years) participated in a 21-day study. Twenty-one grams of cellulose per day was incorporated into the diet by way of snacks and sweets. The food was weighed during the experimental period except for items such as bread, rice and potatoes which were allowed ad libitum. Subjects maintained appetite on both diets. The average daily food and nutrient intake was approximately the same on both diets, except for fiber and cellulose. Participants reported a feeling of fullness at the start of the experimental period but adjusted to it within two weeks (Godara, Kaur and Bhat, 1981).

TABLE IV

COMPARISON OF THE COMPOSITION (g/d)[a] OF AVERAGE WESTERN, TRAPPIST MONKS, YEMENITE AND BEDOUIN DIETS[b]

Ingredient	"Western"	Trappist Monks	Yemenite	Bedouin
Bread	150	600	500	750
Butter, margarine & cream	125	25	10	*
Meat	100-200	--	100	10-25
Egg	50	--	50	5
Cheese	30	*	--	5
Milk	150	250	--	*
'Leben' (buttermilk)	--	250	150	*
Fruit	300	300	200	*
Vegetables	300	300	200	50
Legumes	*	100-150	30	*
Potatoes, macaroni, rice	100	500	100	100
Honey, sugar, chocolate, cakes	100	5	25	25
Oil	--	30	10	10
Protein:				
Total	85 (15)[c]	110 (14)	88 (15)	63 (11)
Vegetable	30	70	58	58
Animal	55	40	30	5
Carbohydrates:				
Total	250 (45)	480 (64)	355 (65)	410 (74)
Mono- & disaccharides	115	40	40	20
'Starch'	135	440	315	390
Fat:				
Total	100 (40)	78 (21)	48 (19)	38 (15)
Saturated fatty acids	50	18	18	8
Oleic acid	32	40	20	12
Linoleic acid	9.5	5.0	6.5	9.0
Cholesterol (g)	0.55	0.16	0.40	0.04
Fiber	5	13	8	7
Energy (MJ/d)	9.4	13.4	9.2	9.4

[a] g/d = grams per day

[b] Groen, 1973, p. 160

[c] Values in parenthesis indicate the energy content (%)

*These ingredients are not always included in the diet.

Painter, Almeida and Colebourne (1972) studied 62 patients with diverticular disease. Of the 62 patients, bran improved the appetite in 26 patients whose appetites had been poor. There was no change in the 35 patients whose appetite were already good.

Eastwood (1969) conducted a study (which lasted for 12 weeks) using 28 monks, members of a Cistercian Trappist Community. Their normal bread was replaced with high-fiber-containing biscuits, increasing fiber intake by 14 g per day. Near the end of the study when a diet history was taken, the intakes of other nutrients had been altered; protein was up 20 percent, fat one percent, and total energy was up four percent.

Fiber and Energy Intake

Some hypotheses have been made postulating how fiber intake might increase satiety and increase caloric intake. Caloric intake can be measured while satiety would be impossible to calculate since it is a subjective sensation (Heaton, 1973).

Literature indicates two factors which determine the size of a meal-palatability and concentration level in the gastrointestinal system. Meal size could then be altered by either a change in palatability and/or a change in the contents of the GI system, degree of bulk, osmotic pressure and concentration (Davis and Collins, 1978).

When rats were given a saccharin-glucose solution with mannitol, the solution was retained in the GI tract for a longer period as compared to the solution given without mannitol. This produced a change in the contents of the GI system and retention of fluid and intake

was suppressed (Davis and Collins, 1978). The increment in satiety is due to the fact that there is a greater amount of undigested material in the intestine with a corresponding increase in sensation of bulk and distention (Heaton, 1973).

According to Van Itallie (1978) no one would argue with the fact that adequate fiber in food decreases the energy density and promotes chewing. In contrast, fiber-deficient foods like sugar and white bread are more concentrated in calories and require little if any masticatory effort (Heaton, 1973; Van Itallie, 1978).

Van Itallie (1978, p. 545) raised the question: "Does the rate at which food is eaten affect the total amount consumed or is it the energy density of the food involved?" One plausable theory is that with rapid eating the stomach becomes full before the GI satiety mechanism has had a chance to become operative. By the time sufficient food has reached the small intestine to activate the satiety signals, one has already overeaten (Van Itallie, 1978).

Currently it is not known whether it is the rate of delivery, increased effort involved in chewing fiber-rich foods, or the caloric density of the diet which alters caloric and nutrient intake (Heaton, 1973; Van Itallie, 1978). Heaton (1973, p. 1419) commented: "I believe fiber to be a natural obstacle to nutrient intake, and suggest foods from which fiber has been removed cause overnutrition. . ."

Food fiber obstructs the intake of energy by (1) displacing available nutrients; (2) requiring chewing which slows intake and induces satiety and (3) reducing the absorption of nutrients from the intestine. Fiber-rich food itself supplies less available energy than similar fiber-deficient food. This, coupled with the fact that fiber binds

water and swells and may require more space in the GI tract than fiber-depleted foods, are two facts pertinent to the displacement of available nutrients (Heaton, 1973).

Chewing has two possible effects on food intake: (1) it slows down intake because of the increased effort involved and (2) it limits intake with the secretion of saliva and prolonged cephalic phase of gastric secretion (Heaton, 1973). "It is commonly believed that the Western way of life fosters casual eating and eating to satisfy an emotional need. Such eating is likely to be deterred by fiber" (Heaton, 1973, p. 1420).

Fiber and Mineral Nutrition

Dietary fiber plays an important role in the absorption, utilization and excretion of other nutrients. The mineral components found in fiber are important such as the calcium found in legumes and vegetables and the silicon located in most cereals (Van Soest, 1978).

> The role of plant fiber in the availability of trace elements is a complicated one because of the probable existence of unavailable forms in the cell wall matrix and also the possible binding to the cation exchange of the fiber surface (Van Soest, 1978, p. 515).

Leveille (1976) concurs by stating that dietary fiber is capable of binding itself to other nutrients in the intestine. Phytic acid is one example of an indigestable component which has been found to bind some trace elements and in experimental animals even produce a deficiency of these trace elements (Leveille, 1976). Simpson, Morris and Cook (1981) report that bran does have an inhibitory effect on iron although the exact mechanism is not known. Reports indicate that the inhibitory effect on iron may be due to phytate, phosphate, or the dietary fiber itself.

Fourteen point one grams of cellulose, hemicellulose and pectin were administered to eight adolescent boys during a 21-day study, with each experimental period only lasting four days. With hemicellulose, there was a significant increase in fecal zinc, copper and magnesium along with a decrease in their retention. Cellulose had the same effect but to a lesser degree while pectin provided the least influence (Drews, Kies and Fox, 1979). The study suggests that dietary fiber being comprised of many fractions will affect minerals according to the type of fiber involved.

Some evidence exists that fiber fractions can bind appreciable amounts of dietary calcium (Kelsay, 1978). Godara, Kaur and Bhat (1981) studied the effects of 21 grams of cellulose on fecal excretion and serum levels of calcium, phosphorus and iron in nine adolescent girls. The fecal excretion level was significantly higher ($p \leq 0.01$) during the experimental period for all three of the minerals than during the control period. Serum levels (for all three) decreased significantly ($p \leq 0.01$) when 21 g of cellulose was ingested for 21 days.

In a metabolically controlled study, male volunteers, ages 19 through 54, were given 26 grams of dietary fiber, corn bran included. The fiber had no apparent effect on cooper or iron absorption but the requirement for calcium was increased with the addition of fiber to the diet (Sandstead et al., 1979). In one study, 14 elderly participants (ages 56 through 89) supplemented their normal diet with 20 g of bran. The serum calcium level was unaltered while the serum iron fell significantly (Persson et al., 1975). There are conflicting results.

The statement was made by Reinhold, Garcia and Garzon (1982 p. 1384): "The ability of dietary fiber to interfere with iron absorption is potentially important for iron nutrition." They stated and reported that fiber might serve a useful purpose by diminishing the tendency for formation of poorly soluble iron hydroxide in the intestine. Ascorbic and citric acids act to release iron from its combination with fiber and stimulate iron absorption (Reinhold, Garcia and Garzon, 1981).

In 1942, Widdowson and McCance compared white and brown bread as to iron absorption. They determined that even though brown bread has large amounts of iron it may not be a good source since iron was not well absorbed.

Results show that high levels of fiber could be detrimental to one's health, placing the body in a disadvantageous situation (Godara, Kaur and Bhat, 1981). At this time, the level at which fiber would be most beneficial and least harmful has yet to be determined.

CHAPTER III

METHODS

A review of related research indicated the need for further studies concerning the effects of dietary fiber from various sources, since fiber varies in its physiological effects according to the type of fiber ingested. This study was undertaken to determine what effects corn fiber would have on the diet of the healthy adult. The research design, sample, data collection, product development, preliminary study, procedures, and analysis of data are outlined in this chapter.

The two-factor experiment with repeated measures on one factor was the design utilized in this study (Figure 1) (Winer, 1962).

> Factorial experiments in which the same experimental unit (generally a subject) is observed under more than one treatment condition require special attention. Experiments of this kind will be referred to as those in which there are repeated measures (Winer, 1962, p. 298).

The analysis of variance is the most often used statistical procedure for this design (Hirck, Cormier, and Bounds, 1974). In the experimental model illustrated below, a_i refers to males, a_p refers to females; b_1 refers to Period I; b_j refers to Period II; b_g refers to Period III.

	$b_1 \cdots b_j \cdots b_g$
a_i	$g_{1_1} \cdots g_{1_j} \cdots g_{1_g}$
$\vdots$	
a_p	$g_{p1} \cdots g_{pj} \cdots g_{pg}$

Figure 1. Experimental Model

Sample

Volunteers were recruited by telephone and signs posed in some buildings on the Oklahoma State University campus. Potential participants filled out an application form (Appendix A), and were screened through a personal interview. Potential participants were not selected for this study if they took mega-vitamin supplements and/or a cholesterol lowering drug; would be out of town during the second and third experimental periods; had unusual eating patterns; had any metabolic diseases; or, in general, showed a lack of commitment.

Twelve participants were chosen: six males ranging in age from 25 to 41, and six females, ages 22 to 34. One female was breast feeding throughout the time of the study. A consent form (Appendix B) and a supplemental data sheet on food use and purchase for home (Appendix C) were then completed by the 12 participants.

Data Collection

Product Development

With the current interest in fiber, Zouranjian (1979), Kuo (1980), and Melouk (1981), investigated the sensory and organolyptic qualities

of baked products with high-protein and high-fiber ingredients. Cochran (1982) studied the effects of corn bran on the sensory and objective qualities of various food systems and reported that corn fiber could be used successfully in vanilla wafers, oatmeal cookies, wheat crackers, and corn bread as a means of increasing fiber in the diet. Matejek (1982) investigated the effects of wheat bran, corn bran, oat bran and corn-oat bran on four bread systems and concluded that they were a feasible means of increasing dietary fiber. Lesieur (1983) conducted a twin study with Matejek (1982) using amaranth grain flour in the same four bread systems. Besides their respective individual studies, Matejek and Lesieur also investigated the inclusion of corn bran into food systems at levels ranging from 1 g to 10 g NDF per serving.

Of 126 dietitians in management surveyed by Conroy (1981), in her study on nutrition labeling, 48 percent preferred measuring units per serving. Having recognized the need for standardized terminology and amounts in determining the fiber content of food systems, Matejek and Lesieur devised a fiber exchange list with NDF determinations per serving size (number of grams NDF per serving) (Matejek, 1982).

To calculate the grams NDF corn fiber per serving, the following formula was used: grams NDF per serving is equal to grams corn bran replaced times percent NDF divided by the number of servings (Matejek, 1982). The fiber exchange list containing 40 items that were developed by Matejek and Lesieur is illustrated in Table V.

TABLE V

CORN BRAN EXCHANGE LIST

Food Product	Serving Size	NDF From Corn Bran Per Serving (grams)
Breads		
Anadama bread	1 slice (16 slices per loaf)	2.5
Bagel	1-3 inch bagel	2.0
Banana nut bread	1 slice (12 slices per loaf)	2.5
Bran rolls	1 roll	2.0
Buttermilk cornmeal waffles	1-5 inch waffle	3.9
Coffee cake	3-inch cube	3.0
Corn bread	2-inch cube	2.0
Corn muffins	1 muffin	3.0
Corn tortillas	1-5 inch tortilla	1.0
Pastry	1/8 pie	2.9
Sticky buns	1 bun	2.0
Whole wheat crackers	1 cracker	0.8
Whole wheat English muffin	1/2 muffin	2.5
Whole wheat pretzel	1-2 inch pretzel	2.0
Desserts		
Butterscotch brownie	1-2 inch brownie	3.0
Carrot cake	1-3 inch cube	7.0
Cheesecake	1 slice (15 slices per cake)	6.0
Chocolate brownie	1-2 inch brownie	3.0
Chocolate cream filling	1/8 pie	2.9
Chocolate cream pie	1/8 pie	5.8
Chocolate eclair	1 eclair	3.9
Lemon refrigerator cookies	1-2 inch cookie	0.5
Oatmeal cookies	1-2 inch cookie	0.3
Vanilla wafers	1-2 inch wafer	1.0

TABLE V (Continued)

Food Product	Serving Size	NDF From Corn Bran Per Serving (grams)
Entrees		
Chicken quiche florentine	1-3 inch cube	4.5
Chicken broccoli chowder	1 cup	6.5
Chili	1 cup	7.1
Crab quiche	1/8 pie	2.9
Individual meat loaf	6 oz.	9.0
Meatballs	4 oz.	4.5
Quiche Lorraine	1/8 pie	2.9
Spinach quiche	1/8 pie	2.9
Tuna salad	1/2 cup	3.0
Tuna sandwich on Anadama bread		8.0
Tuna sandwich on whole wheat English muffin		8.0
Master Mix		
Blueberry muffin	1 muffin	2.0
Cinnamon muffin	1 muffin	3.0
Gingerbread	1-2 inch square	3.5
Pancakes	1-5 inch pancake	3.0
Peanut butter cookies	1-2 inch cookie	1.5

Preliminary Study

A preliminary study was conducted to determine the amount of fiber to be incorporated in self-selected diets, the acceptability of the experimental food systems, and the degree of tolerance of corn bran by healthy adults. Five volunteers made up of Food, Nutrition and Institution Administration staff and graduate students participated in the preliminary study from February 22 to February 26, 1982, where a number of food systems containing a total of 15 g NDF were incorporated into their diets (Menu Schedule, Appendix D).

The daily intake of 15 g NDF corn bran was reasonably tolerated by all participants. At the end of the preliminary study, participants evaluated the fiber-containing food systems subjectively, and completed a questionnaire concerning any change in fluid intake, bowel habit, and their feeling of fullness and comfort level throughout the study (Appendix E). The general consensus from the subjects was that a combination of methods (partake some meals together/take home food) was preferred. This information was considered when the menu schedule was set up for the research.

In determining the level of corn fiber to be used in this study, a review of literature regarding test diets was made. A variety of fiber sources has been reported with levels of fiber ranging from 15 g to 100 g (Truswell and Kay, 1976; Heller, Hackler, Rivecs, Van Soest, Roe, Lewis and Robertson, 1980; Slavin and Marlett, 1980; Godara et al., 1981). Since 15 g NDF corn fiber was reasonably tolerated, the level was increased to 20 g, an amount which was commonly reported in the literature.

Procedures

Based on research such as that of Bell et al. (1981), with modifications and incorporating information gained from the preliminary investigations, this study with Periods I, II, and III was conducted from March 23 to April 26, 1982. The sequence of events is shown in Table VI.

TABLE VI

SEQUENCE OF EVENTS

Period I	- Seven Day Period. Subjects ingest diet normally eaten.
Period II	- Twenty-One Day Period. Subjects ingest normal diet, incorporating experimental food systems, totaling 20g NDF corn fiber per day.
Period III	- Fourteen Day Period. Subjects ingest normal diet, incorporating food systems similar to Period II, but without the addition of corn fiber.

This study was based on self-selected diet, as opposed to a controlled diet in a balance study, except for the incorporation of 20 g NDF corn fiber in Period II. Food systems served during Period II and Period III were prepared considering the subjects' preferences for certain food items in the exchange list. Food records were kept daily by participants, utilizing a specified format (Appendix F).

Food records were seen as the most feasible means for obtaining data since the direct measurement of intake is not only time consuming, but also expensive (Mojonnier and Hall, 1968). The usefullness of information is dependent upon the accuracy of the information reported (Young et al., 1952b). Subjects selected for the study were literate and interested enough in the study to keep the daily food record. "If accurately and consistently kept, this method is objective, even though the patient is the source of data" (Mojonnier and Hall, 1968, p. 289). Subtle differences can occur if subjects consciously or unconsciously alter their eating habits while records are being kept.

Participants were instructed on how to properly complete the food records. Food models were used in order to show the amount or quantity of common food items. Special instructions such as "Suggestions for Keeping Food Records" (Appendix G) and "How to Utilize the Diet Log" (Appendix H) were distributed to all participants. Information on the food record to be provided by participants included descriptions and amounts of food consumed during breakfast, lunch, and dinner. In addition, major ingredients, descriptions such as name brands, forms such as fresh, canned, or frozen, as well as preparation methods were to be recorded.

Food records were completed daily during the six-week study. On the back page of the food records, participants were asked to comment on the number of bowel movements, any discomfort experienced such as gas or cramps, and any other unusual occurrences or activities they have experienced (stress, exercise, illness, lack of sleep) on a day-to-day basis. Food records were collected daily, and records for Saturday and Sundays were turned in on Mondays.

The meal schedule for Periods II and III is shown in Appendix I. Fiber-containing food systems were either picked up or eaten in the Food Research Laboratory. Participants picked up the food systems for Saturdays and Sundays on Fridays.

Data Analysis

Two days per week, totaling 12 days for each of the subjects, were randomly chosen from the food records for data analysis. Information from their records was transcribed onto nutritional analysis system sheets (Appendix J) using food codes and amounts from the Nutritional Analysis Systems of the Department of Experimental Statistics, Louisiana State University, Baton Rouge, Louisiana. Completed sheets were then sent to Louisiana State University where the information was transferred onto computer cards for computer analysis.

A printout with 88 dietary components for each subject per period was sent back to Oklahoma State University. Based on the literature review, 19 variables were examined.

The 19 variables were examined for various reasons. Energy, protein and fat were included since in Eastwood's study (1969) they demonstrated an increase in intake when fiber was incorporated into the diet. Carbohydrate was chosen because it is a major dietary component. Sugar, starch, saturated fat, unsaturated fat, moisture, animal protein and vegetable protein were all examined to try and determine what effects 20 g NDF corn bran would have on the intake of these components. Based on the literature review, the following micronutrients were selected: calcium, iron, phosphorus, zinc, copper, and potassium (Simpson, Morris

and Cook, 1981; Drews, Kies and Fox, 1979; Sandstead et al., 1979; Perrson et al., 1975). Fiber and total fiber, the independent variables in this study, were both examined.

The Louisiana State University Nutritional Analysis System expresses fiber in terms of crude fiber values only. Since it is practically impossible to calculate dietary fiber values from crude fiber values, the 20 g NDF was calculated to determine crude fiber content. According to Staley Manufacturing Company, its' fine grain corn bran contains 16 to 19 percent crude fiber. The middle value 17.5 was used to calculate the crude fiber value of 20 g NDF resulting in 3.5 g. This value was added to the fiber values in Period II, taken from the printout.

F tests resulting from the Analysis of Variance, and Duncan's Multiple Range Test were performed using the Statistical Analysis System (SAS) (Barr and Goodright, 1972).

CHAPTER IV

RESULTS AND DISCUSSION

The effects of adding 20 g NDF corn fiber in specific food products on the self-selected diets of healthy adults are presented in this chapter. Data analyzed to meet the research objectives were obtained from food records completed by the research participants.

Characteristics of Participants

The 12 participants in this study were graduate students, faculty and staff at Oklahoma State University. Three of the subjects were from the Department of Health, Physical Education and Leisure Sciences; three were from the Department of Food, Nutrition and Institution Administration; and six were from various other colleges. The participants' sex, age, weight, height and activity level are described in Table VII. Half of the volunteers chosen for this study were very athletic oriented, therefore, results may not represent the public at large.

Six male subjects ranged in age from 25 to 41, while female subjects were from 22 to 34 years of age. Based on the new height-weight tables, published by the Metropolitan Life Insurance Co. of New York (April 13, 1983), the 12 participants who were assumed to be of medium frame, except for subject code 27 who appeared to have a small frame,

TABLE VII

SAMPLE DESCRIPTION

Subject Code	Sex	Age (yrs.)	Initial Weight (lb.)	Height	Activity/Hours Per Week
11	M	25	163	5'11"	Running, Raquetball, Weight lifting) 14
12	M	26	164	5'11"	Running, Weight lifting) 6
13	M	40	155	6'	Running, Raquetball) 6
14	M	30	180	6'1"	Bike riding) 1
16	M	28	170	6'	Running, Raquetball) 7.5
17	M	41	150	5'9"	-- --
21	F	22	110	5'3"	Running, Raquetball) 3
22	F	25	145	5'6"	Volleyball, Raquetball) 4
24	F	32	129	5'7"	Walking) 2
25	F	29	130	5'4"	Running) 3
26	F	27	160	5'10"	Exercise) 5-6
27	F	34	115	5'4"	Swimming) 0.67

have weights within the ranges indicated for their heights. Activities such as running, weight lifting, and raquetball undertaken by the male subjects ranged from zero to 14 hours per week. In contrast, female subjects spent 40 minutes to six hours on similar activities (Table VII).

Effects of 20 g NDF Corn Fiber on Average Daily Intake of Energy, Macronutrients Micronutrients and Fiber

According to Sex

The F tests indicated significant differences ($p \leq 0.05$) in mean intakes for calories, protein, carbohydrate, sugar, phosphorus, zinc and potassium according to sex (Table VIII). Average energy intake of the male subjects was 2,961 units as compared to 2,111 for female subjects. Female participants consumed on the average 77 g of total protein while male participants averaged 114 g.

The animal protein and vegetable protein intakes for males and females did not differ significantly but were considered worthy of note since values were close to 0.05 level. Males ingested 76 g of animal protein and 37 g of vegetable protein. In contrast, females consumed 49 grams of animal protein and 28 grams of vegetable protein. The mean intake of total carbohydrate was 343 g for men subjects and 233 go for women. Sugar consumption averaged 84 g for female subjects while men averaged as much as 159 g. The average level of phosphorus ingested by males in this study was 2.05 g, whereas females consumed 1.32 g of phosphorus. Zinc, mean intake per day, averaged 16.6 mg for men subjects and 11.6 mg for women subjects. Male subjects have a higher

TABLE VIII

ANALYSIS OF VARIANCE FOR ENERGY, MACRO AND MICRO NUTRIENTS AND FIBER INTAKE

Source	df	Sum of Squares	F Value	Observed Probability Level
Energy				
Sex	1	6501650.03	6.01	0.0341
Error(a)	10	10810912.72		
Period	2	2476308.17	4.96	0.0178
Sex* Period	2	362514.06	0.73	0.4959
Error(b)	20	4989375.78		
Total Protein				
Sex	1	12243.42	5.57	0.0400
Error(a)	10	21987.49		
Period	2	3544.96	3.83	0.0389
Sex* Period	2	548.89	0.59	0.5617
Error(b)	20	9244.09		
Animal Protein				
Sex	1	6394.67	4.11	0.0702
Error(a)	10	15571.32		
Period	2	1302.81	2.19	0.1383
Sex* Period	2	213.48	0.36	0.7031
Error(b)	20	5954.89		
Vegetable Protein				
Sex	1	839.07	3.76	0.0812
Error(a)	10	2231.83		
Period	2	806.01	3.00	0.0726
Sex* Period	2	273.06	1.02	0.3799
Error(b)	20	2687.14		
Total Fat				
Sex	1	8726.67	2.92	0.1183
Error(a)	10	29879.71		
Period	2	10672.05	8.11	0.0026
Sex* Period	2	622.74	0.47	0.6297
Error(b)	20	13153.40		
Saturated Fat				
Sex	1	1124.48	3.89	0.0769
Error(a)	10	2891.94		
Period	2	1324.47	6.41	0.0071
Sex* Period	2	174.75	0.85	0.4441
Error(b)	20	2066.88		

TABLE VIII (Continued)

Source	df	Sum of Squares	F Value	Observed Probability Level
Unsaturated Fat				
Sex	1	2488.35	1.99	0.1887
Error(a)	10	12507.39		
Period	2	3637.31	5.90	0.0097
Sex* Period	2	293.31	0.48	0.6284
Error(b)	20	6167.11		
Total Carbohydrate				
Sex	1	108845.01	6.50	0.0289
Error(a)	10	167578.04		
Period	2	27378.52	3.23	0.0611
Sex* Period	2	8373.92	0.99	0.3902
Error(b)	20	84866.56		
Sugar				
Sex	1	49848.00	10.18	0.0097
Error(a)	10	48980.59		
Period	2	188.84	0.08	0.9210
Sex* Period	2	507.62	0.22	0.8028
Error(b)	20	22858.04		
Starch				
Sex	1	3841.93	1.92	0.1963
Error(a)	10	20038.56		
Period	2	12967.17	7.92	0.0029
Sex* Period	2	2132.41	1.30	0.2938
Error(b)	20	16367.35		
Total Crude Fiber				
Sex	1	36.00	3.43	0.0938
Error(a)	10	104.98		
Period	2	135.22	14.23	0.0001
Sex* Period	2	3.82	0.40	0.6746
Error(b)	20	95.01		
Phosphorus				
Sex	1	4.79	5.39	0.0426
Error(a)	10	8.88		
Period	2	0.68	2.37	0.1195
Sex* Period	2	0.28	0.96	0.3990
Error(b)	20	2.86		

TABLE VIII (Continued)

Source	df	Sum of Squares	F Value	Observed Probability Level
Zinc				
Sex	1	0.0002	7.73	0.0195
Error(a)	10	0.0003		
Period	2	0.0003	18.42	0.0001
Sex* Period	2	0.00004	2.24	0.1323
Error(b)	20	0.0002		
Potassium				
Sex	1	16.73	4.86	0.0520
Error(a)	10	34.40		
Period	2	0.52	0.35	0.7098
Sex* Period	2	1.16	0.78	0.4699
Error(b)	20	14.83		

average mean intake of potassium (3.96 g) than did the female subjects (2.60 g). Male subjects have a higher intake of calories, micronutrients and macronutrients as compared to femals in nine of the nutrients examined. No siginficant differences were found in mean intakes of calcium, fiber, iron, moisture, total fat, saturated fat, unsaturated fat, starch, fiber and copper according to the sex of participants.

According to Dietary Period

Duncan's Multiple Range test was utilized to determine the differences of intake between Periods I, II and III in relation to the following 14 variables: calories, total protein, animal protein, vegetable protein, total fat, saturated fat, unsaturated fat, total carbohydrate, sugar, starch, total fiber, phosphorus, zinc and potassium. The energy intakes for Periods II and III are significantly different ($p < 0.05$) from Period I (Table IX).

The mean energy intake of the 12 participants in this study increased 25 percent in Period II and 26 percent in Period III as compared with Period I. These results are much higher than the results reported by Eastwood (1969), where monks increased their mean energy intake by four percent when dietary fiber was increased by 14 g per day in their diet. This result contradicts the theory of Heaton (1973), that because fiber requires chewing, it suppresses caloric intake.

Some of the food systems developed and utilized in this study were high in energy value and, although researchers intended for them to be eaten in place of some of the food items normally eaten during

TABLE IX

DUNCAN'S MULTIPLE RANGE TESTS FOR VARIABILITY DUE TO PERIOD IN ANALYSIS OF ENERGY, NUTRIENT & FIBER INTAKE[1]

Period	Mean Values: Energy kcal	Total Protein g	Animal Protein[2] g	Vegetable Protein[3] g	Total Fat g	Saturated Fat g	Unsaturated Fat g
1	2164.92[b]	81.78[b]	54.58[a]	26.09[b]	86.98[b]	28.83[b]	49.78[b]
2	2709.33[a]	102.07[a]	63.40[a]	37.44[a]	113.46[a]	37.58[a]	66.08[a]
3	2732.50[a]	103.53[a]	69.22[a]	33.80[ab]	128.64[a]	43.61[a]	73.92[a]

Period	Total Carbohydrate[4] g	Sugar g	Starch g	Total Fiber[5] g	Phosphorus g	Zinc mg	Potassium g
1	252.23[b]	117.57[a]	83.70[b]	5.14[b]	1.51[a]	16.36	3.13[a]
2	319.20[a]	122.45[a]	129.51[a]	9.75[a]	1.70[a]	15.93	3.42a
3	2933.33[ab]	122.40[a]	113.47[a]	6.46[b]	1.85[a]	9.97	3.28[a]

[1]For each column, means not having the same letter (a,b) are significantly different ($p < 0.05$). Means with the same letter are similar and not significantly different.

[2]Not significant at .05 level. From Table VIII, probability = 0.0702.

[3]Not significant at .05 level. From Table VIII, probability = 0.0726.

[4]Not siginficant at .05 level. From Table VIII, probability = 0.0611.

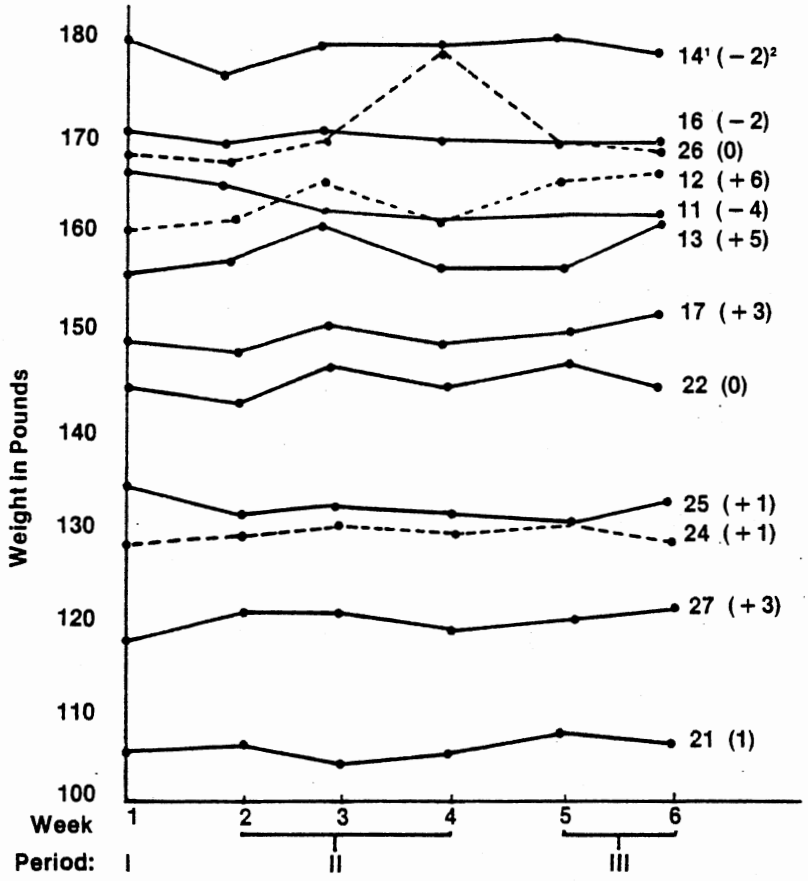
[5]Total intake listed, with 3.5 g crude fiber added to Period II to account for 20 g NDF corn fiber.

the day, they may have been eaten in addition to what was normally consumed by participants. As Van Itallie (1978) proposed, it is either the rate at which food is eaten or the energy density of the food that affects total energy intake.

Participants' weights were monitored weekly and fluctuations in weight are illustrated in Figure 2. Except for Subject 26, who gained 11 pounds during the fourth week, and subsequently lost 10 pounds in the fifth week, all other subjects either gained or lost six pounds or less throughout the study. Changes in weights at the end of the sixth week as compared with the initial weights varied from zero to six pounds (Figure 2).

The mean protein intakes for Periods II and III are significantly different ($p < 0.05$) from the intakes in Period I (Table IX). The mean protein intake of the 12 subjects increased by 24.8 percent and 26.5 percent for Periods II and III, respectively. These results are similar to the results reported by Eastwood (1969), where monks increased their mean protein intake by 20 percent when 14 g dietary fiber was incorporated in their diet.

The mean total fat, saturated fat, unsaturated fat, starch and zinc intakes of the 12 participants in this study during Periods II and III, were significantly different ($p < 0.05$) from the intakes in Period I. There were no significant differences, however, in mean intakes between Periods II and III (Table IX). The mean total fat intake of the 12 participants increased by 30.4 percent and 47.9 percent for Periods II and III, respectively. Eastwood (1969) reported only a one percent increase in fat intake when 14 g dietary fiber was incorporated into the diet of monks, which is much lower than the



1 subject code (male first digit 1, female 2)
2 Changes in weights from initial weight to the end of the sixth week (as compared with initial weights)

Figure 2. Body Weights of Participants During Three Dietary Periods

increase demonstrated in this study. In contrast, no significant differences ($p > 0.05$) existed in the mean intakes of animal protein, sugar, phosphorus and potassium according to dietary periods.

Significant differences in mean vegetable protein intake and mean total carbohydrate intake due to periods were found at probability levels 0.07 and 0.06, respectively. For both nutrients, the mean intake for Period I differed from the mean intake for Period II; however, the mean intake for Period III cannot be distinguished from either of them using Duncan's Multiple Range Test.

The mean intake for total fiber in Period II is significantly different ($p < 0.05$) from those ingested during Periods I and III (Table IX). The amount of total fiber consumed in Period II was about 90 percent more than the amount ingested during Period I. In contrast, the amount consumed during Period III is only 26 percent more than the amount of total fiber ingested during Period I.

This research was not able to determine whether the results were due to the 20 g NDF corn bran solely or due to its combination with the high energy dense experimental food systems.

In Relation to Other Studies

To ascertain how the results of this study compare with results of somewhat similar research, a summary table was prepared showing the energy, nutrient and fiber intakes of subjects in other studies where data are available (Table X). The variables under investigation in the five studies, such as number of subjects, type of fiber used, length of experimental period, self-selected versus controlled, etc.

TABLE X

MEAN ENERGY/NUTRIENT/FIBER INTAKE IN FIVE DIETARY STUDIES

Variables	Study #1 n=12	Study #2 n=10		Study #3 n=6		Study #4 n=8		Study 5 n=12		
	(2 weeks)	Control (4 weeks)	Experimental (3 weeks)	Control (3 weeks)	Experimental (3 weeks)	Control	Experimental	Control Period I (1 week)	Experimental Period II (3 weeks)	Control Period III (2 weeks)
Calories	3432	2380	2380	2803	2755	1954±84***	1954±84***	2165±203.06***	2709±258.43***	2733±252.35***
Total Protein(g)	99	94	97	88	97	95± 5	93± 5	82± 10.95	102± 10.60	104± 10.07
Animal Protein(g)								55± 9.95	63± 7.00	69± 8.14
Vegetable Protein(g)								26± 3.43	37± 5.08	34± 2.85
Total Fat(g)	123	97	96	122	117	82± 3.8	82± 3.8	87± 10.42	113± 10.55	129± 13.30
Saturated Fat(g)						30± 3.8	32± 3.2	29± 2.88	38± 4.20	44± 4.64
Unsaturated Fat(g)						48± 3.7	46± 3.7	50± 6.65	66± 5.68	74± 9.28
Total Carbohydrate (g)	488	324	319	351	339	209± 9	211±11	252± 26.74	319± 35.49	293± 28.73
Sugar(g)								118± 20.08	122± 15.71	122± 16.60
Starch(g)								84± 9.62	130± 10.43	113± 10.93
Total Fiber(g)		23 DF[6]	25 DF	3.6 CF[7]	116 CF	20± 1.3 DF	43± 1.3 DF	5± 0.81 CF	10± 0.77 CF	6.46± 0.75 CF
Phosphorus(mg)								1.51± 0.18	1.70± 0.22	1.85± 0.22
Zinc(mg)								0.01± 0.00	0.02± 0.00	0.02± 0.00
Potassium(mg)								3.13± 0.44	3.42± 0.38	3.28± 0.41

#1 - Edholm, et al, 1955, p. 290. Food was weighed but not limited in amount. Twelve male cadets chosen for subjects.

#2 - Judd and Truswell, 1981, p. 2063. Rolled oats (125 g. daily) were substituted for cereals and proportion of the flour. Fat and energy intakes were adjusted in control period to coincide with experimental period. Six men and four women selected as subjects.

#3 - Jenkins, Hill and Cummings, 1975, p. 1409. 36 g. of wheat fiber incorporated into metabolically controlled diets. Six men chosen as subjects.

#4 - Kirby et al, 1981, p. 825. 100 g. of oat-bran per day provided in muffins and hot cereals. Control diet identical with experimental die in energy, carbohydrate, protein, and fat content. Eight males chosen as subjects.

#5 - Current study: 20 g. NDF corn bran incorporated into self-selected diet during the experimental period.

[6] Dietary Fiber
[7] Crude Fiber

*** Standard Error of the Mean

are dissimilar; hence, objective comparisons cannot be made from the summary table. Data are merely illustrated to glean findings of other researchers in similar dietary studies.

In Studies #2, #3, #4 and #5, fiber was the variable under study; hence there was an increase in fiber during experimental periods. All four studies (#2, #3, #4 and #5) varied in the kind of fiber incorporated into the study. Rolled oats (125 g) used in Study #2 resulted in a 2 g increase in dietary fiber. When 100 g of oat-bran was incorporated into the diet during Study #4, the intake of dietary fiber rose an average of 23 g. Intakes of variables, other than fiber, were controlled in Studies #2, #3 and #4. Crude fiber intake rose by an average of 8 g when 36 g of wheat fiber was fed daily during the experimental period of Study #3. In the current study (Study #5) participants consumed a self-selected diet with the addition of 20 g NDF corn bran during Period II. This resulted in an average increase of 5 g crude fiber per day (Table X).

In Study #3, caloric intake decreased during the experimental period which is not true of Study #5 since energy intake increased by 25 percent. Study #1 shows the highest intake of calories which was partly due to the strenuous activity cadets experienced during basic training (Table X).

Total protein increased during the experimental period as compared to the control period (Period I) in Study #3 and #5. Saturated fat and unsaturated fat increased from Period I to Period II to Period III, as did total fat, in Study #5, whereas total fat intake decreased during the experimental period of Study #3. The values for unsaturated

fat and saturated fat during the control period of Study #4 are within a one to two gram range with the values expressed in the current study during Period I, experimental values are higher in this study as compared to Study #4 (Table X). Total carbohydrate decreased during the experimental period for both Study #2 and #3 while it increased in the current study.

Effects of 20 g NDF Corn Bran on Bowel Habits

In addition to the daily food records, each participant recorded number of bowel movements everyday and described any gastrointestinal discomfort perceived as well as unusual conditions experienced such as exercise, lack of sleep, stress, illness and breath hydrogen test. A summary of the bowel movements per week for each participant in the six week study is presented in Table XI. The average number of bowel movements per participant per week did increase during Period II which supports the work done by Bell et al., (1981), Cowgill and Sullivan (1933), Floch and Fuchs (1978). Some of the gastrointestinal discomfort experienced include gas production, cramps, nausea and "intestinal noise". Although the consistency of the stool was not always recorded, many of the participants reported that their stools were loose during Period II.

During Period II, the number of bowel movements for Subjects 11 and 21 increased by as much as ten. Subjects 12, 13, 16, 25, 26 and 27 all experienced a moderate increase (five to seven) in bowel movements during Period II. Subject 14 did not experience an increase in bowel movements, but remained relatively constant throughout the

TABLE XI

SUMMARY OF PARTICIPANTS BOWEL MOVEMENTS AND PERCEIVED DISCOMFORT[a]

	PERIOD I		PERIOD II						PERIOD III			
	Week I		Week II		Week III		Week IV		Week V		Week VI	
Subject Code	Bowel Movements	Discomfort	Bowel Movements	Discomfort	Bowel Movements	Discomfort	Bowel Movements	Discomfort	Bowel Movements	Discomfort	Bowel Movements	Discomfort
11	12	--	23	gas-3 times	22	gas-1 time	22	cramps-1 time gas-1 time	17	gas-2 times	24	--
12	12	--	14	gas-4 times	17	--	14	gas-1 time	14	--	14	--
13	9	--	13	nausea-1 time	15	cramps-4 times gas-4 times	26	cramps-4 times gas-3 times	6	gas-1 time	6	--
14	7	--	7	cramps-1 time gas-1 time	6	--	7	gas-1 time	5	--	4	--
16	9	--	15	gas-5 times	14	gas-6 times	12	gas-5 times	14	--	13	gas-2 times
17	3	--	2	--	4	--	5	gas-2 times	3	--	4	--
21	10	gas-1 time	20	cramps-2 times gas-2 times	20	cramps-1 time gas-1 time	12	--	13	--	11	--
22	8	--	6	--	8	--	3	--	5	--	4	--
24	7	--	5	gas-1 time	6	--	9	--	5	--	4	---
25	3	cramps-2 times gas-3 times	6	gas-7 times	10	gas-7 times	7	gas-6 times	6	gas-6 times	7	gas-7 times
26	7	gas-1 time	10	intestinal noise-2 times	8	--	13	--	10	--	10	--
27	21	gas-1 time	22	--	27	--	26	--	13	--	18	--
TOTAL[b]	9		12		13		13		9		10	

[a]Numbers in column represent totals per week

[b]Average number of bowel movements per participant per week.

entire study. In contrast, Subjects 17, 22 and 24 first experienced a slight decrease in the number of bowel movements during Period II before a slight increase occurred.

Subject 13 reported being extremely uncomfortable towards the end of Period II (Week IV), in terms of cramps and loose stools. The same subject indicated that during the last three days of Period III (Week V), his stools became very hard, and that his stool consistency returned to normal during the sixth week. Subject 25 experienced increased perception of gas production during Periods II and III. A few of the participants reported experiencing feeling of fullness and distended abdomen during Period II.

CHAPTER V

SUMMARY, RECOMMENDATIONS AND IMPLICATIONS

Today, fiber is the focus of much research. Controversy still exists as to its definition and method of analysis. This, coupled with the fact that fiber fractions vary in chemical structure cause it to be an elusive, complicated field of study. The components of fiber, celluloses, hemicellulose, lignin, pectin, gums and mucilages, vary in physiological function, which frustrates the attempt to link fiber to diseases and changes associated with calories and nutrients.

This research was conducted to study the effects of including foods containing corn bran (20 g NDF) to otherwise self-selected diets in healthy adults. Experimental food systems were developed with the inclusion of corn bran at levels ranging from 0.3 to 9 g NDF per unit or serving. A fiber exchange list (Table V) with NDF determinations per serving size (number of grams per serving) was developed and utilized in the study.

A preliminary study was conducted to determine the level of fiber to be incorporated in self-selected diets in relation to product acceptability and degree of tolerance of corn bran. Based on the preliminary study, 20 g NDF corn cran was the amount investigated in this study. The decision for participants to partake some meals together in the Food

Research Laboratory and other meals at their own discretion was also a result of the preliminary study. Twelve volunteers were selected from students, staff and faculty at Oklahoma State University according to specifications described in Chapter III.

Most of the food intake of subjects in this study was self-selected since participants choose most foods, incorporating designated food systems into their usual diets in Periods II and III. The study lasted six weeks as outlined in Table VI. Participants kept food records daily which provided the data for this research. Twelve days for each of the subjects, two days per week, were chosen at random from the food records for the purpose of data analysis.

Summary

Although dietary fiber values are preferred over crude fiber values, the values expressed in this study are in terms of crude fiber, which is the value listed in the nutrient data bank utilized. Unless otherwise indicated, 0.05 is the level of significance accepted in the study.

According to the analysis of variance, intakes of energy, protein, carbohydrate, sugar, phosphorus, zinc, and potassium are significantly different ($p < 0.05$) between sexes (Table VIII). Compared to females, males had a higher intake of calories, macronutrients and micronutrients. In this study, the mean intakes of calcium, fiber, iron, moisture, copper, total fat, saturated fat, unsaturated fat, starch, animal protein, vegetable protein and fiber proved to be insignificant at the 0.05 level.

To determine the mean separation of intakes among the three dietary periods, Duncan's Multiple Range Test was performed. Fourteen variables were considered: calories, protein, animal protein, vegetable protein, total fat, saturated fat, unsaturated fat, total carbohydrate, sugar, starch, total fiber, phosphorus, zinc and potassium.

Periods II and III were significantly different ($p < 0.05$) from Period I in calcium, total protein, total fat, saturated fat, unsaturated fat, starch and zinc. There was no significant difference between Periods II and III (Table IX).

Significant differences in mean vegetable protein intake and mean total carbohydrate intake due to periods were found at probability levels of 0.07 and 0.06, respectively. For both nutrients, the mean intake for Period I differed from the mean intake for Period II; however, the mean intake for Period III cannot be distinguished from either Period I or II.

Total crude fiber intake in Period II was significantly different ($p < 0.05$) from both Periods I and III. Consumption of fiber in Period II was 90 percent greater than in Period I, while Period III was only 26 percent more than the amount ingested during Period I. There was no significant difference according to period for animal protein, sugar, phosphorus, and potassium (Table IX).

Recommendations

Corn bran was successfully incorporated into 40 food systems which comprised an exchange list (Table V) from which menus were prepared for the volunteers. Several of the food systems utilized were high in

energy density which might confuse results. The development and use of low energy density food systems is proposed. More control over choice of food systems from the exchange list is needed, especially for menus on the weekends. Additional studies utilizing corn bran of various particle size should be explored.

Since fiber varies in its physiological function according to type (source and/or components), additional information is needed before conclusions could be drawn concerning the effect of fiber. Very few fiber studies are concerned with the effect fiber has on energy, macronutrient and micronutrient intakes, hence further research should focus on these areas. Besides sex and period, activity level and age should be investigated in a similar study. It is recommended that studies be conducted to compare the effects of different levels of fiber intake on energy, macronutrient and micronutrient intakes.

Very limited information is known on the fiber content of foods available to consumers. Research in this area could provide researchers with more accurate data on the individuals' daily intake of fiber from foods normally consumed.

Implications

Self-selected studies provide a more practical, and less expensive method of obtaining dietary information as compared with controlled dietary studies. Self-selected diets also allow participants more freedom relative to food choices, meal times, and dining locations. This method can provide pertinent data for research purposes as long as there are appropriate controls built into the study, and when used in conjunction with objective tests such as breath H_2, stool transit time and blood analysis.

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APPENDIXES

APPENDIX A

APPLICATION FORM

APPLICATION FOR PARTICIPATION IN CORN FIBER STUDY

NAME_____ DATE_____

RACE_____ BIRTHDATE_____ SEX_____

HEIGHT_____in. WEIGHT_____lb. TRICEPS SKINFOLD_____mm

Have you ever had: Diabetes?_____ Hypercholesteremia?_____
Heart disease?_____ Anemia?_____ Hypoglycemia?_____

Females: Are you pregnant?_____ Taking oral contraceptives?_____

Do you now or have you ever had: Gastritis?_____ Colitis?_____
Other serious GI disorder?_____

Are you frequently constipated?_____ have diarrhea?_____

Do you take laxatives?_____ If so, how often?_____

How much time (_____) and how frequently(_____) do you engage in vigorous activity (kind?_____)?

How much has your weight fluctuated in the last 6 months?_____

Do you expect major, stressful events between now and May 1?
_____oral exams _____birth of a child _____major deadlines (as a thesis)

_____major decision (new job, etc.) _____marriage _____other:_____

How many days a week do you eat:									How many days a week do you eat this meal/snack away from home?						
Breakfast	1	2	3	4	5	6	7	--	1	2	3	4	5	6	7
Mid-morning	1	2	3	4	5	6	7	--	1	2	3	4	5	6	7
Lunch	1	2	3	4	5	6	7	--	1	2	3	4	5	6	7
Mid-afternoon	1	2	3	4	5	6	7	--	1	2	3	4	5	6	7
Dinner	1	2	3	4	5	6	7	--	1	2	3	4	5	6	7
Evening	1	2	3	4	5	6	7	--	1	2	3	4	5	6	7

Check the types of food most frequently eaten at each time:

	Hot main dish	Cold main dish (sandwich, cereal)	Veg. (other than potato)	Fruit	Breads etc.	Dessert, Sweets	Nutri. beverage (juice, milk)	other beverage
Breakfast								
Midmorning								
Lunch								
Midafternoon								
Dinner								
Evening								

Please recall everything you ate or drank yesterday.—

APPENDIX B

CONSENT FORM

OKLAHOMA STATE UNIVERSITY
College of Home Economics
Department of Food, Nutrition and Institution Administration

CONSENT TO PARTICIPATE IN RESEARCH

The study of "Effects of Corn Fiber," conducted by the Department of FNIA _____, has been described to me. As a participant, I will be required to:

1) Follow a prescribed, regular meal pattern, selecting foods I ordinarily eat but including specific fiber-containing products to be furnished by project personnel.

2) Keep a record of all foods I eat during the study, and the quantities eaten.

3) Consume amounts of food that will cause me to maintain my present weight.

4) Provide blood, fecal and breath specimens for laboratory analysis near the end of each of the three parts of the study.

5) Remain in Stillwater during the 3-week part of the study when high-fiber foods are provided or, if necessary to leave, make arrangements ahead of time for obtaining food, etc.

I have been assured that properly trained personnel will conduct the study, and I assume whatever risk may be involved in the procedures above. This does not imply a waivor of my rights in case of negligence. While I may withdraw at any time, I understand that my usefulness in the study and any compensation to be made to me will be contingent upon my completion of all parts of the study.

Having been informed of the nature of this study requirements for participation, I consent to the conditions herein described if I am selected.

_____
Participant Signature

_____
Date

_____
Investigator

APPENDIX C

SUPPLEMENT DATA ON FOOD USE AND PURCHASE FOR HOME

FORM D4

Supplemental data on food use and purchase for home

Subject number _____ Subject name _____ Date_____ Interviewer_____

1. What type of vegetables do you usually use?
   ___ canned
   ___ frozen
   ___ fresh

2. What spread is used at the table? ___ butter ___ stick margarine ___ soft margarine

3. What kind of fat is used to fry?
   ___ solid shortening (brand = _____)
   ___ oil (brand = _____)

4. What kind of fat do you usually use in baking? ___ butter ___ shortening
   ___ margarine ___ oil

5. What kind of milk is usually bought for your daughter to drink?

   ___ Skim ___ ½% ___ 1-1/½% ___ 2% ___ whole ___ chocolate skim
   ___ chocolate whole

6. Does your child usually take vitamins? ___ Yes ___ No

7. What ground meat is usually purchased?

   ___ regular ground beef (60-70% lean) ___ extra lean (80-90% lean)
   ___ ground chuck ___ ground round

8. Do you trim fat from meat before cooking it? ___ Yes ___ No ___ Part of it

9. Does your daughter like to eat the fat that is cooked on meat? ___ Yes ___ No

10. Do you skin chicken before cooking? ___ Yes ___ No

11. What kind of salt to you buy? ___ Plain ___ Iodized

APPENDIX D

PRELIMINARY FIBER STUDY

MENU SCHEDULE

Preliminary Fiber Study
Menu Schedule
February 22 - 26

Time & Day	Breakfast[1]	Lunch[1]	Other[2]
2/22 M	1 Cinnamon Muffin 3 gm NDF	--	4 sl. Anadama Bread 10 gm NDF 1 Brownie 3 gm NDF
2/23 T	2-5" Waffles 7.8 gm NDF Orange Juice Milk	--	1 Pretzel 2.0 gm NDF 3 Peanut Butter Cookies 4.5 gm
2/24 W	--	1 cup Chili 7.1 gm NDF 1-1" cube Cornbread 2 gm NDF 1/8 Chocolate Cream Pie 5.8 gm NDF	--
2/25 Th	2-5" Pancakes 6.0 gm NDF Orange Juice Milk	--	2 sl. Anadama Bread 5.0 gm NDF 1 Butterscotch Brownie 3.0 gm NDF
2/26 Fr	1-Whole Wheat English Muffin 5.0 gm	1 cup Chicken Broccoli Chowder 6.5 gm NDF 1/8 Crab Quiche 2.9 gm NDF	--

[1]Items eaten in Food Laboratory.

[2]Items eaten throughout the day at subjects discretion.

APPENDIX E

QUESTIONNAIRE

PRELIMINARY FIBER STUDY

1. Did you experience increased intestinal gas while eating the corn fiber products? _____yes _____no If yes, how many hours was it after you began the study? _____6 _____12 _____24 _____36 _____other

2. Did you notice any change in liquid intake? _____yes _____no If yes, explain.

3. Did you experience abdominal cramps or any general discomfort? _____yes _____no If yes, explain.

4. Did you notice any change in bowel habits during the five days of this study? _____yes _____no If yes, how long was it before you noticed the change? _____6 _____12 _____24 _____36 _____other
How long did this change persist? _____6 _____12 _____24 _____36 _____other

5. Did you notice a change in number of bowel excretions? _____yes _____no

6. Did you notice changed volume in bowel feces? _____yes _____no

7. Did you notice a color change from your normal feces? _____yes _____no
If yes, what was the color change?

8. Did you experience any of the following?
diarrhea _____
constipation _____
looser, softer stools but no actual diarrhea_____

9. Did you experience a feeling of fullness for a shorter or longer time after a meal? Explain.

C O R N F I B E R P R O D U C T S
SUBJECTIVE EVALUATION

Please rank the products according to the following preference scale:


Liked very much


Liked


So - So


Disliked


Disliked very much

PRODUCTS					
Cinnamon Muffin					
Anadama Bread					
Chocolate Brownie					
Orange Buttermilk Waffles					
Whole Wheat Pretzel					
Peanut Butter Cookies					
Chilli					
Cornbread					
Chocolate Cream Pie					
Pancakes					
Butterscotch Brownie					
Whole Wheat English Muffin					
Chicken Broccoli Chowder					
Quiche					

Did you prefer eating the high fiber products in the food lab or taking them home? Explain.

APPENDIX F

FOOD RECORD

NAME _____ RECORD FOR: S M T W T F S DATE: ____ PAGE___

TIME OF DAY	WHERE EATEN	FOOD	DESCRIPTION	AMOUNT

(front)

INITIALS _____

UNUSUAL conditions: check or describe -

Exercise -

Lack of sleep -

Stress -

Illnesses -

Breath hydrogen test today -

Number of bowel movements today _____

Comments:

Any gastrointestinal discomfort, gas, etc.?

Comments:

(back)

APPENDIX G

SUGGESTIONS FOR KEEPING FOOD RECORDS

SUGGESTIONS FOR KEEPING FOOD RECORDS

Except for food provided as part of study, you may choose whatever you wish to eat - if
- -meal pattern is consistent week to week
- -you record what is eaten
- -you do not change significantly in weight

Keep forms handy; record food as soon as possible.

Describe foods:
- -Was it raw, boiled, fried?
- -Was it buttered, sweetened, with a sauce?
- -What were main ingredients of mixed dishes?

Give amounts of all foods. It may help to:
- -Note package sizes; report, eg., 1 1-oz. Milky Way; 1/4 or 7 oz. pkg. Fritos.
- -Record either as weight or as volume
- -Use premeasured containers. At home, check capacity of glass with measuring cup; use measuring cup to serve your plate.
- -Keep a small ruler handy to measure, eg., diameter of apple, thickness of ham slice.

Record brand names (1/2 c. Cheerios; 1 reg. MacDonald's fries)

Only list items we furnish, as "brownie (FNIA)"

Be very careful recording: fruit, vegetables, cereals & breads

Turn in records daily in HEW 407 (except weekend). Each page must have name & date.

Record "where eaten" only if away from home.

Each day, complete information on back of form.

APPENDIX H

HOW TO UTILIZE THE DIET LOG

DIET LOG

Instructions:

This study permits you to choose most of the food you eat, so long as you are consistent in following an agreed on meal pattern. We must know, however, everything you actually eat.

Record each food eaten as soon as possible. Be as exact as you can. Record amounts in whatever units are convenient. Note weights of unit packages eaten (3/4 oz. candy bar, 10oz. bottle of cola, 20 g. bag of chips, 1 of 18 slices of bread in 1# loaf, etc.). Use brand names (1 Big Mac, 2 of 8 slices (or ¼) of frozen Jeno's Sausage Pizza, 3/4 c. Cheerios). Be particularly careful in describing breads, cereals, fruits, vegetables. Indicate if raw or cooked; whole grain, enriched. Check labels of multi-grain cereals, etc. and note order of main ingredients ("whole wheat, rye & enriched white wheat flours"). Remember to list method of preparation (1 large egg, scrambled in milk + margarine), and added substances (sugar in tea, butter on vegetable).

Short Cuts: 1) Foods provided by the project staff should just be listed; they will come in standard portions.

2) Measure the capacity of the cup and glass you use at home. report this the first time and then merely say how many glasses (2/3 glass juice).

3) Buy the same brands throughout study so you don't have to describe in detail after the first time.

At the end of each day, after completing diet record, please take a moment to make comments on the record about number of bowel movements, any discomfort (gas, cramps), unusual activities or occurrences (stress, exercise, lack of sleep, illness, etc.).

Name_____ Date_____ Day of week_____

Meal Period	Food	Description	Amount	Where Eaten
Breakfast				
etc.				

APPENDIX I

MEAL SCHEDULE

Menu Schedule for Period II, Week II

Time & Day	Breakfast[1]	Lunch[1]	Other[2]
3/23 T	--	--	4 sl. Anadama Bread 10 gm NDF 2-2" Butterscotch Brownies 6 gm NDF 3-2" Peanut Butter Cook. 4.5 gm NDF
3/24 W	--	1 cup Chili 7.0 gm NDF 2 Corn Muffins 6.0 gm NDF 1-3" cube Carrot Cake 7.0 gm NDF	--
3/25 Th	--	--	3 sl Anadama Bread 8.0 gm NDF 6 Whole Wheat Crackers 5.0 gm NDF 1 Whole Wheat English Muffin 5.0 gm NDF 6-2" Oatmeal Cookies 2.0 gm NDF
3/26 Fr	2-5" Buttermilk Waffles 7.8 gm NDF Orange Juice	--	2-2" Chocolate Brownies 6.0 gm NDF 2 Bran Rolls 4.0 gm NDF 4-Whole Wheat Crackers 3.2 gm NDF
3/27 Sat	--	--	Choice of Anadama Bread and Banana Bread to total 20 NDF
3/28 Sun	--	--	Choice of Anadama Bread and Banana Bread to total 20 NDF

[1] Items eaten in Food Laboratory

[2] Items eaten throughout the day at subjects discretion.

Menu Schedule for Period II, Week III

Time & Day	Breakfast[1]	Lunch[1]	Other[2]
3/29 M	2 Sticky Buns 4.0 gm NDF 1-3" cube Chicken Quiche Florentine 4.5 gm NDF Orange Juice	--	2 sl. Anadama Bread 5.0 gm NDF 2-2" Butterscotch Brownies 6.0 gm NDF
3/30 T	--	--	2 sl. Anadama Bread 5.0 gm NDF 2-2" Whole Wheat Pretzels 4.0 gm NDF 8 oz. Meatballs & Sauce 10.0 gm NDF
3/31 W	--	2/8 Spinach Quiche 6.0 gm NDF 2 sl. Zucchini Bread 5.0 gm NDF 1 sl. Cheesecake 6.0 gm NDF	2 Oatmeal Cookies 0.6 gm NDF 4 Whole Wheat Crackers 2.4 gm NDF
4/1 Th	--	--	1 Whole Wheat English Muffin 5 gm NDF 3 sl. Anadama Bread 8.0 gm NDF 2-2" Chocolate Brownies 6.0 gm NDF
4/2 Fr	2-5" Pancakes 6.0 NDF	--	1 Tuna Sandwich on Whole Wheat English Muffin 8.0 gm NDF 6 Whole Wheat Crackers 4.8 gm NDF 4-2" Oatmeal Cookies 1.2 gm NDF
4/3 Sat	--	--	Free Choice to total 20.0 gm NDF
4/4 Sun	--	--	Free Choice to total 20.0 gm NDF

[1]Items eaten in Food Laboratory

[2]Items eaten throughout the day at subjects discretion.

Menu Schedule for Period II, Week IV

Time & Day	Breakfast[1]	Lunch[1]	Other[2]
4/5 M	2/8 Quiche Lorraine 6.0 gm NDF 2-3" cubes Coffee Cake 6.0 gm NDF P.A. Juice or Orange Juice	--	8-2" Oatmeal Cookies 2.4 gm NDF 1 Whole Wheat English Muffin 5.0 gm NDF
4/6 T	--	--	8 oz. Meatballs w/ Sauce 9.0 gm NDF 2 sl. Anadama Bread 5.0 gm NDF 2 Blueberry Muffins 4.0 gm NDF 4-2" Lemon Refrigerator Cookies 2.0 gm NDF
4/7 W	--	6 oz. Meatloaf 9.0 gm NDF Au Gratin Potatoes 4.0 gm NDF 2-2" cubes Gingerbread 7.0 gm NDF	--
4/8 Th	--	--	1 Whole Wheat English Muffin 5.0 gm NDF 2-3" Bagels 4.0 gm NDF 3-2" Chocolate Brownies 9.0 gm NDF 2-2" Oatmeal Cookies 1.0 gm NDF
4/9 Fr	3 Sticky Buns 6.0 gm NDF	--	1 Tuna Sandwich on Whole White English Muffin 8.0 gm NDF 2-2" Butterscotch Brownie 6.0 gm NDF
4/10 Sat.	--	--	Free Choice to total 20.0 gm NDF
4/11 Sun	--	--	Free Choice to total 20.0 gm NDF

[1] Items eaten in Food Laboratory
[2] Items eaten throughout the day at subjects discretion.

Menu Schedule for Period II, Week V

Time & Day	Breakfast[1]	Lunch[1]	Other[2]
4/12 M	3-5" Pancakes 9.0 gm NDF	--	1-3" cube Coffee Cake 3.0 gm NDF 6-2" Lemon Refrigerator Cookies 3.0 gm NDF 15-2" Oatmeal Cookies 4.5 gm NDF
		Period III Week V (continued)	
4/13 T	--	--	4 sl. Anadama Bread 2-2" Brownies (Chocolate or Butterscotch) 3-2" Peanut Butter Cookies
4/14 W	--	--	1 cup Chili 2 Corn Muffins 1-3" cube Carrot Cake
4/15 Th	--	--	2 sl. Anadama Bread 6 Whole Wheat Crackers 1 Whole Wheat English Muffin 4 Oatmeal Cookies
4/16 Fri	2-5" Buttermilk Waffles	--	2-2" Chocolate Brownies 2 Bran Rolls 4 Whole Wheat Crackers
4/17 Sat	--	--	4 sl. Anadama Bread 4 sl. Banana Nut Bread
4/18 Sun	--	--	4 sl. Anadama Bread 4 sl. Banana Nut Bread

[1]Items eaten in Food Laboratory

[2]Items eaten throughout the day at subjects discretion.

Menu Schedule for Period III, Week VI

Time & Day	Breakfast[1]	Lunch[1]	Other[2]
4/19 M	2 Sticky Buns 1-3" cube Chicken Quiche Florentine Orange Juice	--	2 sl. Anadama Bread 2-2" cube Butterscotch Brownie
4/20 T	--	--	4 sl. Anadama Bread 8 oz. Meatballs & Sauce
4/21 W	--	--	Swiss Cheese 4 Whole Wheat crackers 1 sl. Cheesecake 6 Whole Wheat Thins 4 Oatmeal Cookies
4/22 Th	--	--	1 Whole Wheat English Muffin 2 sl. Anadama Bread 2-2" Chocolate Brownies
4/23 Fri	2-5" Pancakes	--	1 Tuna Sandwich 4 Wheat Thins 2 Oatmeal Cookies
4/24 Sat	--	--	Free Choice to total 20 gm NDF
4/25 Sun	--	--	Free Choice to total 20 gm NDF
4/26	1-3" cube Coffee Cake 1/8 Quiche Lorraine	--	8-2" Oatmeal Cookies 1 Whole Wheat English Muffin

[1]Items eaten in Food Laboratory.

[2]Items eaten throughout the day at subjects discretion

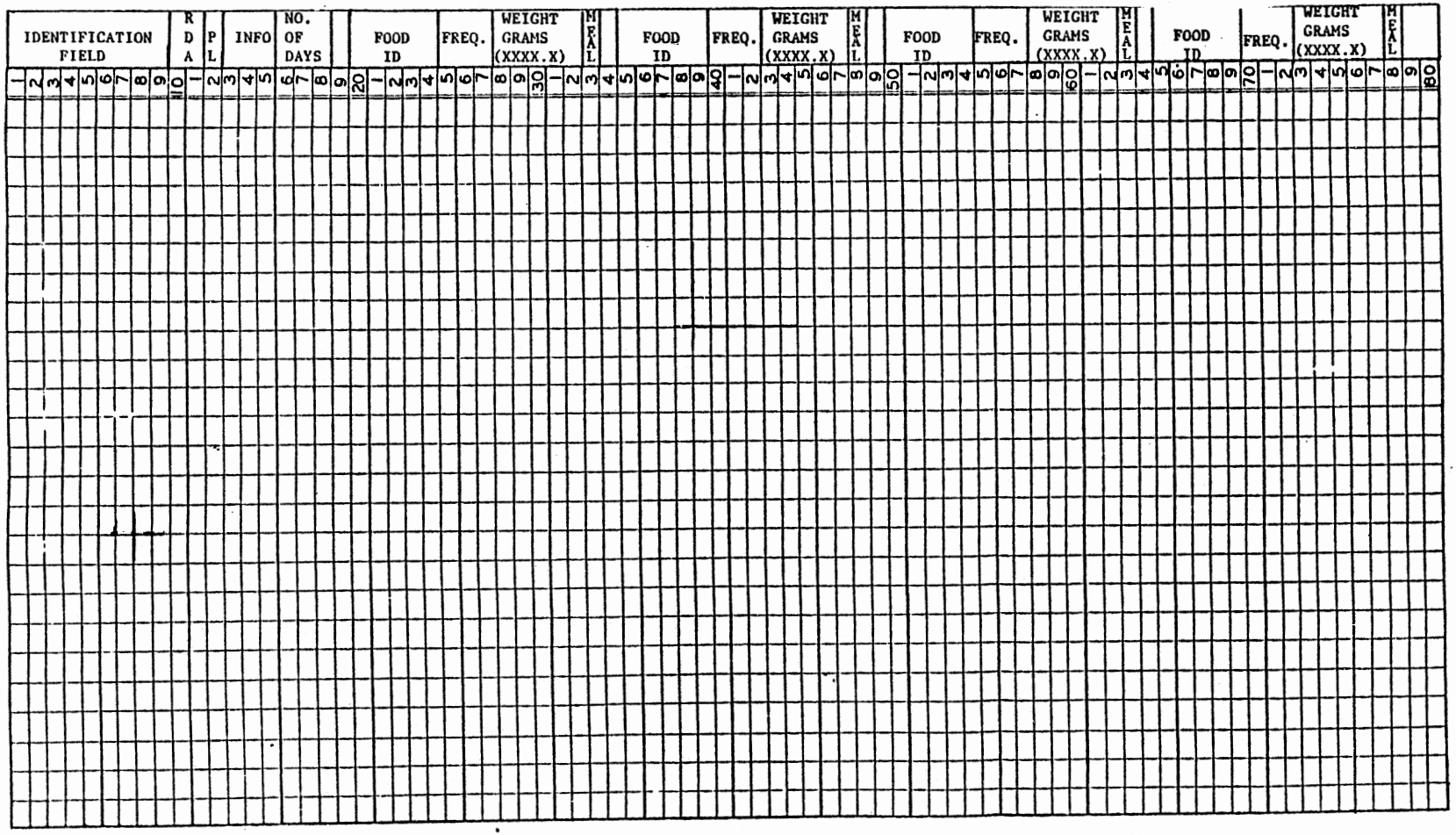
APPENDIX J

NUTRITIONAL ANALYSIS SYSTEM SHEETS

CASE_____

NUTRITIONAL ANALYSIS SYSTEM

PAGE ___ OF ___ PAGES



DEPARTMENT OF EXPERIMENTAL STATISTICS, LSU, BATON ROUGE, LA 70803

APPENDIX K

AVERAGE INTAKE PER PERIOD FOR EACH SUBJECT

TABLE XII

AVERAGE INTAKE PER PERIOD FOR EACH SUBJECT

SUBJECT	PERIOD	CALORIES	MOISTURE	TOTAL PROTEIN	ANIMAL PROTEIN	VEGETABLE PROTEIN	TOTAL FAT	SATURATED FATTY ACIDS	UNSATURATED FATTY ACIDS	STARCH
11	1	1825	1529	43.2	38.7	3.2	51.2	18.7	28.9	8.2
12	1	3513	2009	176.8	148.9	25.2	170.5	53.9	103.9	114.8
13	1	3346	2808	97.9	45.8	52.0	125.1	32.4	73.8	126.6
14	1	1524	1160	56.7	30.9	25.8	63.6	24.0	35.2	71.2
16	1	2464	1340	112.4	84.9	25.7	97.1	32.5	52.8	85.1
17	1	2021	1756	82.3	50.0	30.8	73.4	26.6	36.4	93.0
21	1	1491	1287	58.3	34.9	26.5	48.1	15.9	26.0	83.6
22	1	1343	1908	35.3	20.6	12.3	53.2	23.9	26.5	54.8
24	1	1786	1419	59.4	27.8	31.6	74.8	22.5	46.9	61.6
25	1	2593	1665	94.2	63.9	25.6	118.0	37.3	69.3	101.1
26	1	1808	1562	75.0	54.1	19.8	81.8	27.7	49.1	78.1
27	1	2265	1696	89.9	54.5	34.6	86.9	30.6	48.6	126.3
11	2	2958	1398	91.8	47.0	45.6	124.2	37.1	78.5	140.5
12	2	3391	1945	155.5	122.3	30.2	147.5	56.2	81.0	121.8
13	2	3114	1830	109.3	71.2	31.9	120.4	38.8	67.3	140.4
14	2	2488	1498	93.4	62.6	31.7	112.6	35.1	69.5	130.6
16	2	4986	2081	191.8	93.8	90.3	185.7	71.1	91.8	230.7
17	2	2211	1249	90.0	51.2	39.7	94.0	32.6	52.6	106.2
21	2	1764	1238	70.6	41.3	30.7	57.3	19.5	32.3	110.7
22	2	1542	1669	59.4	36.1	22.0	63.7	23.0	35.3	79.0
24	2	2501	1616	86.8	57.5	30.4	125.5	37.6	79.5	118.4
25	2	2902	1292	102.4	67.4	34.9	146.2	45.6	90.1	132.6
26	2	2418	1313	83.3	51.7	31.4	95.6	26.7	61.4	129.2
27	2	2237	1798	90.5	58.7	30.5	88.8	27.6	53.6	114.0
11	3	2325	1439	90.6	58.4	27.5	110.2	30.6	63.8	80.9
12	3	3334	2185	135.6	105.2	31.1	152.5	53.0	85.4	104.7
13	3	4700	2752	179.3	131.1	50.9	234.4	82.2	150.9	197.4
14	3	3310	2027	127.3	84.8	44.9	150.0	49.4	89.5	157.2
16	3	3526	1646	140.7	85.6	50.5	143.5	42.6	81.4	148.2
17	3	2254	1225	81.6	50.7	33.9	98.8	43.9	45.6	88.5
21	3	2144	1252	67.1	39.4	27.4	83.1	32.3	42.5	93.4
22	3	1615	1791	64.9	35.3	23.7	76.8	24.0	41.8	77.6
24	3	2222	1389	90.8	63.2	30.2	111.5	39.0	64.1	91.8
25	3	3147	1649	102.9	72.1	33.5	182.0	60.6	109.9	136.5
26	3	2063	1138	79.8	51.9	20.8	110.5	34.4	61.0	80.1
27	3	2150	1569	81.7	52.9	31.2	90.4	31.3	51.1	105.3

TABLE XII (Continued)

SUBJECT	PERIOD	TOTAL CARBOHYDRATES	SUGARS	CRUDE FIBER	TOTAL FIBER	CALCUIM	IRON	PHOSPHOROUS	ZINC	COPPER	POTASSIUM
11	1	205.7	148.6	0.3	0.3	0.257	0.0068	0.801	0.00894	0.7106	1.054
12	1	327.7	164.0	4.3	4.3	1.373	0.0190	2.493	0.01715	2.0419	6.646
13	1	486.8	305.0	10.0	10.0	1.381	0.0167	2.575	0.01215	2.3128	4.586
14	1	189.3	88.9	5.6	5.6	0.409	0.0167	1.065	0.00726	1.0901	2.278
16	1	291.5	104.8	5.2	5.2	1.512	0.0622	2.223	0.01139	1.3168	3.958
17	1	213.7	86.0	8.7	8.7	0.881	0.0150	1.424	0.01157	1.3274	2.913
21	1	212.3	70.9	6.6	6.6	0.945	0.0105	1.260	0.00933	1.6259	2.798
22	1	122.1	24.9	1.4	1.4	0.512	0.0075	0.804	0.00514	0.8925	1.133
24	1	218.1	120.1	6.2	6.2	0.639	0.0145	1.141	0.00747	1.6752	3.008
25	1	267.4	89.9	4.2	4.2	1.135	0.0108	1.588	0.00959	4.3567	3.164
26	1	198.4	80.6	2.8	2.8	0.605	0.0123	1.156	0.01056	1.3954	2.149
27	1	293.7	127.1	6.4	6.4	1.137	0.0131	1.621	0.00909	2.4702	3.888
11	2	376.2	179.4	8.0	11.5	0.615	0.0185	1.534	0.01415	3.0864	3.147
12	2	363.7	192.4	4.2	7.7	1.465	0.0226	2.396	0.02580	1.8846	4.645
13	2	404.6	191.8	7.4	10.9	1.078	0.0225	2.052	0.01974	2.0346	4.136
14	2	280.3	108.8	5.3	8.8	0.669	0.0169	1.456	0.01275	1.6106	3.292
16	2	653.2	213.6	13.7	17.2	2.541	0.0717	3.770	0.02343	3.2892	6.831
17	2	244.2	82.8	6.5	10.0	0.591	0.0162	1.272	0.01297	1.5790	2.880
21	2	238.2	82.2	4.9	8.4	0.768	0.0124	1.153	0.01232	2.2796	2.680
22	2	188.5	65.6	5.4	8.9	0.553	0.0103	0.881	0.01044	2.6721	1.627
24	2	242.8	83.0	4.7	8.2	0.803	0.0150	1.511	0.01122	1.5819	2.983
25	2	271.5	86.3	6.5	10.0	1.105	0.0173	1.693	0.01558	3.6724	3.024
26	2	303.2	91.4	3.8	7.3	0.646	0.0152	1.235	0.01530	1.3351	2.633
27	2	264.0	92.1	4.6	8.1	0.782	0.0162	1.449	0.01751	2.4210	3.220
11	3	236.6	110.4	5.4	5.4	0.974	0.0141	1.621	0.01449	1.8986	2.613
12	3	361.7	186.0	4.5	4.5	1.248	0.0196	2.159	0.02089	1.8590	4.712
13	3	489.6	231.4	10.6	10.6	1.203	0.0254	3.691	0.02974	2.9359	6.331
14	3	375.0	171.1	8.8	8.8	1.049	0.0314	1.981	0.02029	3.6152	4.545
16	3	432.5	180.9	11.9	11.9	2.092	0.0517	2.839	0.02215	2.7631	4.549
17	3	246.0	98.4	4.7	4.7	0.914	0.0115	1.575	0.01387	1.1625	2.187
21	3	284.6	119.9	6.2	6.2	0.840	0.0112	1.214	0.00985	3.2371	2.110
22	3	169.6	37.7	4.6	4.6	0.562	0.0125	1.100	0.01198	1.0015	1.498
24	3	216.3	84.8	6.0	6.0	1.102	0.0133	1.673	0.01413	2.6661	3.095
25	3	264.1	80.7	4.2	4.2	1.219	0.0158	1.679	0.01429	5.1724	2.385
26	3	190.9	66.5	4.0	4.0	0.743	0.0127	1.306	0.01123	1.1383	2.440
27	3	253.1	101.0	6.6	6.6	0.724	0.0150	1.333	0.01342	1.5590	2.927

VITA

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