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A Model for Estimating Available Iron from Total Nutrient Intakes

Ann Marie Black
Utah State University

A MODEL FOR ESTIMATING AVAILABLE IRON FROM TOTAL NUTRIENT INTAKES

by

Ann Marie Black

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ABSTRACT

A Model for Estimating Available Iron
from Total Nutrient Intakes

by

Ann Marie Black, Master of Science
Utah State University, 1986

Major Professor: Dr. Arthur W. Mahoney
Department: Nutrition and Food Sciences

Factors which affect iron bioavailability have been repeatedly and extensively investigated. A model, derived from these studies, has been developed for estimating available iron from meal data. However, many dietary surveys report only average daily intakes of iron, and do not report the iron present in single meals. No model to estimate available iron from daily iron intake has been presented in the literature.

Dietary questionnaires were kept for two nonconsecutive weekdays by 355 male and 382 female Utah school children, mean age 7.5 years, assisted by their parents, and recorded by household measure. Data, first recorded as meals eaten, were used to develop three models for the estimation of available iron from total daily iron intake. It was concluded that available iron can be estimated from total iron intake by two of these models, as compared with the currently used model, which estimates available iron from data recorded by meal.

Additionally, meal patterns of those factors involved with the estimation of available iron were investigated. The intake of dietary ascorbic acid and total iron was found to be evenly distributed among meals; approximately 10% of these nutrients was consumed as snacks. Of the meat, fish, poultry and the iron in those products consumed; 36% was taken at lunch, and 54% at dinner. Only 5% of the meat, fish, and poultry iron was consumed as snacks. The available iron distribution for breakfast, lunch, dinner, and snacks was 21.0%, 30.8%, 42.5% and 5.7%, respectively.

Previous studies have investigated the characteristics of diets which provide 9 mg of iron per 1000 kcal of energy consumed. These diets have been shown to include larger portions of vegetables, fruits, and cereal products. In this study, these high-iron dense characteristics were studied as they pertain to total available iron intake. It was concluded that the high-iron dense diet receives more total available iron from the nonheme iron than from the heme iron consumed. Thus, it is conceivable that those dietary characteristics shown to provide a high-iron dense diet may also provide a high available iron intake.

(187 pages)

INTRODUCTION AND OBJECTIVES

Introduction

In recent years factors which affect iron bioavailability have been extensively investigated. It has been shown that consumed iron forms two distinct "pools", known as heme and nonheme iron, differentiated by method of absorption (Clydesdale, 1983; Cook, 1983; Hallberg, 1981a; Morris, 1983). Nonheme iron is absorbed from a common mixture of iron formed when several food items are ingested simultaneously and can be either enhanced or inhibited by action of other food components on the solubility of the uncomplexed iron (Clydesdale, 1983; Cook, 1983; Hallberg, 1981a). Heme iron absorption is generally considered not to be affected by other simultaneously ingested foods. These findings have been used to develop a model for the estimation of available iron (Monsen et al., 1978; Monsen and Balintfy, 1982). Traditionally, however, most dietary surveys of iron consumption have tended only to report average daily intakes of total iron. Few studies have investigated the consumption patterns of heme iron, nonheme iron and the enhancement factors of nonheme iron absorption used in Monsen's model to estimate total available iron (Acosta et al., 1984; Bull and Buss, 1980; Gibson et al., 1984; Hallberg, 1981a; Raper et al., 1984). It is this author's contention that information concerning common intake patterns and characteristics of heme iron, nonheme iron and the enhancement factors of nonheme iron absorption, used in Monsen's model, should be investigated, and a simple model to estimate available iron intake from total iron consumed be developed to allow future researchers an ability to obtain a better understanding of iron nutriture.

Objectives

The objectives of this work, therefore, are two-fold. First, to determine the general pattern of consumption of total iron; heme iron; nonheme iron; and the iron from meat, fish, poultry; and the enhancement factors of nonheme iron absorption namely, ascorbic acid, and meat, fish or poultry, for each meal/snack; as well as to determine the actual dietary characteristics involved in consuming an adequate available iron intake. The second objective of this work is to propose a model for the estimation of available iron from total daily nutrient intakes and to compare this model(s) with the Monsen et al. (1978) model. The proposed model would be the simplest model that gives an estimate of available iron from total daily nutrient intakes and is not statistically different from the Monsen model.

Thesis Structure and Content

This thesis is comprised of three main parts, or articles, in addition to those sections normally included. These parts are as follows: Part I - Meal Pattern of Available Iron, Ascorbic Acid, and Meat, Fish, Poultry Intakes by School Children; Part II - A Model to Estimate Available Iron Intake from Total Iron Consumed; and Part III - Available Iron Intakes of School Children Consuming High Iron Density Diets. These three main parts were written with publication in mind and thus have been streamlined. Therefore all details of method and/or all facets normally explored in a review of literature have not been included in the articles themselves. However, a major Review of Literature section has been included in the body of this manuscript and four appendices have been added which include all details of methods used so that further research may be spared the same problems.

The methods used in carrying out the objectives of this work consisted of: 1) the calculation by computer of available iron using Monsen's model which estimates available iron from data collected on a per meal basis; and 2) the development and use of three computer generated models to estimate available iron intake based on data recorded as daily totals of nutrients consumed; 3) statistical comparisons of the three models and the control (i.e. the Monsen method); 4) generation of common intake patterns of heme iron, nonheme iron and the enhancement factors of nonheme iron absorption used in Monsen et al. (1978) model; and 5) delineation of the possible dietary characteristics involved in a diet providing adequate total available iron intake. The methods by which each model was calculated, as well as how the common intake patterns described above were generated, are described in general in the three articles or "main parts" of this work. Actual step by step computations used in designing the computer programs which ultimately produced the models are outlined in Appendix B. The contents of the computer files to determine the models, upon which the statistical analyses were run, are listed in alphabetical order, by file name, in Appendix C. The actual step by step procedures used in running the statistics on this data are documented in Appendix D. The contents of the computer files used in determing the statistical analyses are listed in alphabetical order, by file name, in Appendix E.

In addition, when generating the models the amount of heme iron present was computed in two ways: 1) using a figure of 40% of the meat iron contained in the meat, fish, or poultry products consumed as the value for heme iron; and 2) by using "actual heme iron" values. The actual heme values were obtained from the literature or derived from information contained in the literature (Greenberg et al., 1957; Hallberg, 1981a; McDonald's System Inc., 1977; Monsen et al., 1978; Saffle, 1973; Schricker et al., 1982; USDA

1963a; USDA 1974; USDA 1963b; Vahabzadeh, 1982). A listing of the actual heme values; grams meat, fish, poultry; and meat iron contained in the meat, fish, poultry products consumed by the participants of this study can be found in Table 16 of Appendix A. The equations and sources used to derive this information for each meat, fish, poultry product consumed can be found in Table 18 of Appendix A. The heme iron values calculated using a figure of 40% of the meat iron are referred to in this manuscript as "calculated heme iron". The heme iron values derived from the literature are referred to in this manuscript, and in some of the computer files, as "actual heme iron" or "value derived heme iron ", as in a value derived from the literature.

REVIEW OF LITERATURE

Introduction

In recent years, factors which affect iron bioavailability have been extensively investigated and this information reviewed (Clydesdale, 1983; Cook, 1983; Dallman et al., 1980; Finch and Cook, 1984; Hallberg, 1981a; Hallberg, 1981b; Morck et al., 1983; Morris, 1983). In general, the factors which appear to affect absorption can be categorized as follows: the nature of the iron itself, other food components consumed simultaneously with the iron such as the enhancement/inhibitory factors of nonheme iron absorption, and the iron status of the individual.

The Nature of Iron

Early human studies used radioactive "tags" or sources of iron which had been biosynthetically incorporated into a food (intrinsic tag) to measure absorption. Results of such studies have been summarized by Bothwell et al. (1979). Later it was observed that a trace amount of iron simply added to the food (extrinsic tag) could also be used to measure iron absorption (Bjorn-Rasmussen et al., 1974; Cook et al., 1972; Hallberg and Bjorn-Rasmussen, 1972; Layrisse et al., 1974). In most cases actual absorption, both with the intrinsic and extrinsic tag of radioiron, is determined by either measuring erythrocyte incorporation or whole-body retention of radioiron (Bothwell et al., 1979). From these investigations several specific concepts were developed with regard to the nature of iron.

It has been shown that dietary iron consists of two distinct "pools", known as heme and nonheme iron, differentiated by method of absorption (Clydesdale, 1983; Cook, 1983; Hallberg and Bjorn-Rasmussen, 1972; Hallberg, 1981a; Morris, 1983). Heme iron, derived mainly from the hemoglobin and myoglobin of meat products, constitutes 10%-15% of the iron consumed in Western diets (Hallberg, 1981b; Rossander et al., 1979). Heme iron is assimilated directly into the mucosal cells as an iron-porphyrin complex (Clydesdale, 1983; Cook, 1983) and once inside the cell the iron is released by a heme-splitting enzyme (Cook and Monsen, 1977; Dallman et al., 1980). Since heme iron is absorbed in such a manner, it is generally considered not to be affected by other simultaneously ingested foods or food components (Hallberg, 1981b; Hussain et al., 1965; Layrisse et al., 1969). This has been shown to be especially true for ascorbic acid and phytates (Hallberg and Solvell, 1967; Turnbull et al., 1962).

Nonheme iron is derived from foods of vegetable origin and also partially from meat. It constitutes the majority of the iron consumed in Western diets (Hallberg, 1981b;

Rossander et al., 1979). Nonheme iron is absorbed from that common mixture of iron formed when several food items are ingested simultaneously or when nonheme containing foods are ingested singly. It is broken down and reduced to the more soluble ferrous form upon digestion in the acid environment of the stomach (Dallman et al., 1980). Nonheme iron absorption can be enhanced or inhibited by action of other food components on the solubility of the uncomplexed iron (Clydesdale, 1983; Cook, 1983; Hallberg, 1981a). The most potent enhancers of nonheme iron absorption appear to be ascorbic acid and meat (Cook, 1983; Hallberg, 1981a; Morris, 1983; Riddick and Woteki, 1983). Actual mechanisms for nonheme iron absorption have been reviewed by Rao and Prabhavthi (1978).

Enhancement Factors of Nonheme Iron Absorption

Early studies on the enhancement effect of ascorbic acid showed that the absorption of nonheme iron from maize, wheat, soya, and rice could be increased 3-7 fold through the addition of ascorbic acid, often in the form of fruit (Bjorn-Rasmussen and Hallberg, 1974; Callender et al., 1970; Layrisse et al., 1974; Moore and Dubach, 1951; Rossander et al., 1979; Sayers et al., 1973; Sayers et al., 1974). The enhancement effect of ascorbic acid has been shown to be just as effective whether derived from food sources or synthetic supplements (Morris, 1983) and a meal containing 100 mg of ascorbic acid is considered a meal of high bioavailability of iron (Monsen et al., 1978). The role of ascorbate in iron absorption has been extensively reviewed by Bibeau and Clydesdale (1976). In addition, it has been shown that when ascorbic acid is added to a semipurified or standard meal no decrease in the rate of enhancement effect occurs until a dose of 1000 mg is reached (Cook and Monsen, 1977). The variability in enhancement effect that has been seen (i.e. 3-7 fold increases) may be a function of pH-substrate interactions (Clydesdale, 1983) and differs from food to food.

The presence of meat also appears to be a potent enhancer of nonheme iron absorption and produces a 2-4 fold increase (Cook, 1983; Hallberg, 1981a; Monsen et al., 1978; Morck et al., 1983; Morris, 1983). First reported by Layrisse et al. (1968) this observation has been repeated by others including a study using fish (Cook et al., 1972; Cook and Monsen, 1976; Hallberg et al., 1978; Layrisse et al., 1974; Martinez-Torres and Layrisse, 1970). Other animal products such as milk, cheese, and eggs do not seem to have an enhancement effect on nonheme iron absorption (Cook and Monsen, 1976). The mechanism by which meat, fish, and poultry promote absorption is unknown although the chelation of nonheme iron by amino acids to facilitate absorption has been proposed (Morck et al., 1983).

Inhibitory Factors of Nonheme Iron Absorption

Data on effect of phytate on nonheme iron absorption are contradictory. Beginning with McCance and Widdowson (1943), there have been several studies which show that either sodium phytate, or phytate phosphorus, added to the diet inhibit nonheme iron absorption (Apte and Venkatachalam, 1962; Davies and Nightingale, 1975; Foy et al., 1959; Hallberg and Solvell, 1967; Hussain and Patwardhan, 1959; Sharpe et al., 1950; Turnbull et al., 1962). However, other studies indicate that phytate has little or no effect on iron absorption (Cowan et al., 1966; Fuhr and Steenbock, 1943; Hunter, 1981; Rahotra et al., 1973). Such discrepancies have been attributed to: 1) experimental design; 2) the fact inhibitory effects have not been seen with naturally occurring phytates, or with dephytinized materials, but have only been seen with added sodium phytate; 3) and to the fact that fiber may actually be the inhibitory substance, since it is often associated with phytate (Anonymous, 1967; Cowan et al., 1966; Simpson et al., 1981).

With regard to fiber being the inhibitory factor, this, too, appears inconclusive. Several studies show inhibitory effects of fiber, yet none has delineated a clear cause and effect relationship (Callender and Warner 1970; Cook et al., 1983; Kelsay et al., 1979; Reinhold et al., 1981). For example, Reinhold et al. (1981) have been able to quantify the amount of iron bound by the neutral detergent fiber (NDF) of maize and wheat. They showed that the NDF of wheat bound 0.38 mg of iron per gram of NDF and the NDF of maize bound 0.30 mg of iron per gram of NDF. However, Reinhold et al. (1981) also showed that the iron binding by fiber was strongly inhibited by ascorbic, citric, phytic acids, cysteine, phosphorus and calcium. The amount of iron bound depended on concentration, pH, amount of fiber present, and the presence or absence of the aforementioned inhibitors of binding.

In reviewing several absorption studies, nonheme iron absorption ranged from 1% to 4%, when either phytate or fiber were present (Acosta et al., 1984; Elwood et al., 1970; Gillooly et al., 1984). It appears that there is no conclusive evidence in the literature regarding the amount of phytate or fiber that causes a specified decrease in available iron.

Tea and coffee also appear to be inhibitory. Several studies have shown both to be inhibitors of iron absorption, although the effects were greater with tea than with coffee, and the decrease in absorption varied from study to study (Bagepall et al., 1982; deAlarcon et al., 1979; Disler et al., 1975; Morck et al., 1983). Disler et al. (1975) demonstrated nonheme iron absorption could be decreased as much as 87% from a meal in which tea was consumed. Bagepall et al. (1982) showed a 50% decrease in absorbed iron with one cup of tea. Morck et al. (1983) showed a mean absorption of 1.32% of the nonheme iron from a hamburger meal with tea as the beverage versus a 3.71% absorption from the same meal with water as the beverage. This represented a 64% inhibition. When a cup of coffee was consumed with the hamburger meal a 39% decrease in iron absorption was observed. Derman et al. (1977) also showed a 37% reduction in nonheme absorption with coffee. However, again no quantifiable decrease in iron absorption per amount tea/coffee consumed can be conclusively given.

Iron Status

The absorption of both heme and nonheme iron are influenced by the iron status of the individual in an inverse logarithmic manner (Finch and Cook, 1984; Hallberg, 1981a; Hallberg, 1981b; Monsen et al., 1978; Morris, 1983). The maximum amount of iron that can be absorbed from an adequate diet by iron deficient, nonanemic individuals appears to be 3.5 mg/day but the average iron absorption by deficient, nonanemic individuals appears to be only 2 mg/day (Finch and Cook, 1984; Jacob et al., 1980). Monsen et al. (1978) report that from a low of 2% in iron-replete individuals nonheme iron absorption can increase to 20% in iron deficient individuals, provided abundant enhancers are present. The absorption rate for heme iron in a subject without iron stores, appears to be 35%, while the absorption rate for heme iron in the iron-replete individual appears to be 15% (Monsen et al., 1978). Thus, both heme and nonheme iron absorption rates vary with the iron status of the individual in question.

Monsen's Model To Estimate Available Iron

Assumptions Made in Monsen's Model

These findings with regard to the factors which affect iron bioavailablity have been used to develop a model for the estimation of available iron. At present, this is the only model for the estimation of available iron intakes (Monsen et al., 1978; Monsen and Balintfy, 1982). The assumptions made in this model include:

1. dietary iron is considered to be either heme or nonheme iron. Heme iron is assumed to be 40% of the dietary iron in meat, fish, poultry products. The amount of heme iron available to be absorbed is assumed to be 23% of the total amount of heme iron present.
2. the amount of nonheme iron that is available to be absorbed is determined by the amount enhancement factors (EF) present. A unit of enhancement factor is considered to be one milligram of ascorbic acid and/or one gram of meat, fish, or poultry in a single meal. Each unit of enhancement factor can increase the nonheme iron absorption; 3% at zero units of EF, to 8% at 75 units of

EF. The actual value of nonheme iron absorption is determined by the following equation:

$$\% \text{ absorption} = 3 + 8.93 * \log_e \frac{(EF + 100)}{100}$$

3. inhibitory factors are not to be considered in the calculations. It is noted by the authors that certain inhibitory factors may affect the amount of iron available but are not considered in the calculations.
4. the individual in question has good iron stores. In other words, no enhancement effect, due to low physiological iron stores, is considered.
5. fortification iron, involving iron compounds of low availability, is not included as a separate entity in the calculations.

Modifications of Monsen's Model

Monsen's model (Monsen et al. 1978; Monsen and Balintfy, 1982) can only be used with data that have been collected on a per meal basis. No model to estimate available iron from total iron intake has been presented in the literature. Bull and Buss (1980), in reporting average iron intakes of British households, estimated available iron based on total iron intake. This, however, was a modification of Monsen's model (Monsen et al. 1978; Monsen and Balintfy, 1982), and the results were not compared to those obtained by using the Monsen's exact procedure (Monsen et al. 1978; Monsen and Balintfy, 1982). It remains uncertain as to how this method might compare.

The procedure of Bull and Buss (1980) consisted of the following:

1. All foods, except meat products, were considered to contain nonheme iron, which was estimated to be absorbed at a 5% level.
2. Sixty percent of the iron in beef, lamb, poultry and other red meats was considered to be heme iron. Forty percent of the iron in pork, bacon, ham, liver, fish, and other meats was considered to be heme iron. Heme iron was assumed to be absorbed at a rate of 23% of the total amount consumed.
3. Fortification iron, which was calculated from recipes and information obtained from manufacturers, was considered to be absorbed at a rate of 1% or 5%. From the results of this study it was shown that fortification iron made up 11% of the total iron consumed.
4. The amounts of heme, nonheme and fortification iron considered available were then summed and the estimate of total available iron was recorded.

Possible Questions as to the Assumptions Made in Monsen's Model

Possible questions as to the assumptions made in Monsen's method (Monsen et al. 1978; Monsen and Balintfy, 1982), either stated or implied, must be considered. There are five areas which should be investigated: the amount of fortification iron that can be absorbed, the effect of cooking/heat on ascorbic acid, the assumptions concerning heme absorption, iron status of individuals and the effects of inhibitory substances on nonheme iron absorption.

Iron Fortification. Iron fortification has been practiced for many years and much confusion still surrounds the bioavailability of such products. Researchers have reported relative bioavailability values from 10%-90% of a reference dose (Hurrell, 1985). This has been attributed to a variety of causes (Patrick, 1985). However, actual absorption rates have only been reported to be in the range which is imposed by Monsen's equation (Monsen et al. 1978; Monsen and Balintfy, 1982) for nonheme iron absorption (Cook et al., 1973, Elwood, 1965; Lee and Clydesdale, 1979; Steinkamp et al., 1955). Thus, it appears that treating the absorption of fortification iron in Monsen's model (Monsen et al. 1978; Monsen and Balintfy, 1982) as if it were natural nonheme iron is a prudent action.

Ascorbic Acid. It has long been known that ascorbic acid is destroyed by heat. Sayers et al. (1973) showed significant decreases in iron absorption. This was attributed to the high temperatures needed for baking. Monsen et al. (1978) concluded that because much the vitamin C contained in the meal may be destroyed by heating and/or oxidation during the handling of the food, estimates of ascorbic acid should be based on the actual amount contained in the meal as eaten by each individual. Therefore, if these types of estimates were used, this problem should then be corrected.

Heme Iron. Cook and Monsen (1976) showed that 30%-40% of the iron in pork, liver, fish, and 50%-60% of the iron in beef, lamb, and chicken, is heme iron. Monsen et al. (1978), in proposing their model for the estimation of available iron, stated that the proportion of heme iron in different types of animal tissue varies but concluded that these differences were not sufficiently great magnitude to justify separate factors for each type of animal tissue. As a result, they assumed 40% of the iron contained in a meat product to be heme iron. Data published by Schricker et al. (1982) showed the average amount of heme iron contained in pork, lamb, and beef to be 49%, 57% and 62%, respectively, using an adaptation of the method used by Cook and Monsen (1976). Park et al. (1983), from a review of literature, estimated muscles from cows and steers contain 40%-80% of their iron as hemoglobin or myoglobin (i.e. heme iron) while Hazell et al. (1978) estimated that 70% of meat iron is pigment. Recent evidence by Oellingrath and Slinde (1985) showed that the heme iron content of ground beef may be closer to 85%. They suggested that this may be due to the fact that heat was used in the determination of heme iron content by Cook and Monsen (1976). It has previously been shown that heat or chemical processing can convert heme to nonheme iron through the oxidative cleavage of the porphyrin ring (Schricker and Miller, 1983) and thus, ultimately decrease the amount of heme iron present. Schricker et al. (1982) concluded that because of the wide variability in heme iron content of different species of animals and in the muscles of the same species, mean heme values may be of limited value in evaluating and predicting iron availability from a meal. Data from Jansuittivechakul et al. (1985) show that the heme content in raw meat, autoclaved meat, 5 minute boiled meat, 30 minute boiled meat, 90 minute boiled meat, rare baked meat, medium baked meat and well done baked meat to be 58%, 21%, 53%, 43%, 38%, 56%, 47%, and 44% of total iron, respectively. These meats were shown to be of a similar iron bioavailabiltiy (Jansuittivechakul et al., 1985). Averaging the eight methods reported gives a mean absorption of 45% for all methods considered. Therefore, it appears from this information that the Monsen method (Monsen et al. 1978; Monsen and Balintfy, 1982) may actually underestimate the heme content of meat using the figure of 40% of total meat, fish, poultry iron as an estimate of heme content.

However, there is also some evidence (Kotula and Lusby, 1982) that total iron content may be overestimated in Handbook 8 (USDA, 1963b). It appears that Handbook 8 (USDA, 1963b), from which most nutrient intake data is derived, lists a value of 3.2 mg iron per 100g beef which is consistent with the iron content of older animals (Kotula and Lusby, 1982). Yet, the USDA Choice and Good grades of meat, generally consumed in this country, come from younger animals. Since iron content increases with the age of the animal (Kotula and Lusby, 1982; Wolfe and Ono, 1980) it can be concluded that the values commonly given for iron in Handbook 8 (USDA, 1963b) are higher than can be expected in slaughtered beef. Kotula and Lusby (1982) concluded the iron values listed in Handbook 8 (USDA, 1963b) are 34% higher than the actual content of beef carcasses. If heme content is derived as a percent of total iron appearing in meat, as is done in Monsen's model (Monsen et al. 1978; Monsen and Balintfy, 1982), there is the possiblity of overestimating heme iron content.

Iron Status. With regard to iron status, Monsen et al. (1978) assumed, in estimating available iron, that the individual in question has iron stores of 500 mg and no increase in absorption should occur due to low physiological stores. Average stores, however, are estimated to be 1000 mg of iron in the adult male and 300 mg in the adult menstruating female (Brittenham et al., 1981). Valberg et al. (1976) showed mean serum ferritin levels for a random sample of Canadian women 20-39 years of age to be 23 ng/ml. This suggests average iron stores for this group to be approximately 230 mg, given 1 ng/ml serum ferritin is equivalent to 10 mg of storage iron (Jacobs et al., 1972). Data from National Health and Nutrition Examination Survey, 1976-1980 or NHANES II (Expert Scientific Working Group, 1985) indicate the highest percents of abnormal ferritin values using a ferritin model which measures serum ferritin, transferritin saturation, and erthrocyte protoporphyrin to be found in nonpregnant women aged 15-19 years, males aged 11-14 years, and nonpregnant women aged 20-44 years. A low serum ferritin in this model, was defined as less than 10 ng/ml for ages 3-14 years and less than 12 ng/ml for ages 15-74 years. Using the conversion factor of 10 mg of storage iron per 1 ng/ml serum ferritin (Jacobs et al., 1972), NHANES II (Expert Scientific Working Group, 1985) data indicate 12.1% of males 11-14 years have iron stores of 100 mg or less; 9.6% of nonpregnant women 20-44 years, and 14.2% of nonpregnant women 15-19 years, have iron stores of less than 120 mg. The possibility that iron stores may be lower especially for women of childbearing age, than assumed by Monsen's model (Monsen et al. 1978; Monsen and Balintfy, 1982) for estimation of available iron, is real. Thus, more iron may be available due to low physiological stores. According to Gibson et al. (1984) Monsen's model (Monsen et al. 1978; Monsen and Balintfy, 1982) grossly overestimates the number of premenopausal Canadian women in their study who are receiving inadequate intakes of available iron by as much a 40%. Therefore, the available iron estimated by this model especially with regard to menstruating women and possibly teenage males may be low.

Inhibitory Substances. As previously discussed phytate, fiber, tea, and coffee all may inhibit nonheme iron absorption. In each case the data are inconclusive and cannot be quantified to any degree of satisfaction. It should be noted that because of this, it appears such factors were not included in Monsen's model (Monsen et al., 1978; Monsen and Balintfy, 1982) for the estimation of nonheme iron absorption and the available iron estimated by this approach may be lower for diets high in inhibitory substances.

Iron Requirements

Recommended Dietary Allowances and Iron Density

It has been shown that there are three major factors which affect iron bioavailability and from this research a model to estimate available iron has been developed. However, actual need with regard to available iron, as well as total iron, has not been addressed.

The highest Recommended Dietary Allowance (RDA) for iron in the United States (i.e. 18 mg) can be found in the following age categories: females 11-14, 15-18, 23 to 50 years, and males 11-14, 15-18 years (NAS, 1980). This allowance expressed in terms of mg of iron recommended per 1000 kcal of suggested energy intake (nutrient density), for the categories females 11-14, 15-18, 19-22, 23-50 years, males, 11-14, 15-18 years is 8.2 mg, 8.6 mg, 8.6 mg, 9.0 mg, 6.7 mg, 6.4 mg, respectively (Hansen and Wyse, 1980; NAS, 1980). Survey data, however, indicate the average American consumes only 6-7 mg of iron per 1000 kcal. This has been shown for women (USDA, 1980; USDA, 1985; USDHHS, 1983; Pao, 1981), for children (Hendricks et al., 1981; USDA, 1980; USDA, 1985; USDHEW-Ten-State Nutrition Survey, 1970), and for men (USDA, 1980; Richard and Roberge, 1982). Comparisons between the RDA iron allowance (NAS, 1980), and iron intake data from the Nationwide Food Consumption Survey (USDA, 1980), in terms of iron density, for selected age groups are made in Table 1.

Table 1. Comparisons between iron requirements and actual iron intake in terms of iron density for select age groups.

Age Group (years)	Females (mg Fe/1000 kcal)		Males (mg Fe/1000 kcal)	
	RDA	Intake[a]	RDA	Intake[a]
9-11	8.2	6.4	6.7	6.6
12-14	8.6[b]	6.1	6.4[b]	6.5
15-18	8.6[b]	6.3	3.5[b]	6.3
19-22	8.6[b]	6.5	3.7	6.2
23-34	9.0[b]	6.6	3.7	6.5
35-50	9.0[b]	7.1	4.2	6.8
51-64	4.2	7.5	4.2	7.2
65-74	4.2	7.3	4.2	7.4
75 +	4.9	7.4	4.9	7.4

[a] The intake data are taken from the Nationwide Food Consumption Survey (USDA, 1980).

[b] Age groups in which the RDA for iron is 18 mg/day or 9 mg of iron per 1000 kcal suggested energy intake for that particular age group.

From these data then it appears only women 12 to 50 years consistently consume less total iron per 1000 kcal than recommended and thus could be considered "at risk" assuming that all groups are meeting their calorie allowances.

Iron Status of Children

However, biochemical data from NHANES II (Expert Scientific Working Group, 1985) show a relatively high prevalence of poor iron status in children, 1-2 years of age; 11-14 year old males; and 15-44 year old females.

For infants and children age 6 months to 3 years the RDA is 15 mg of iron per day (NAS, 1980). The standard for iron density for 1-3 year-olds based on the average suggested energy intake, in kcal, is 11.5 mg iron/1000 kcal (Hansen and Wyse, 1980; NAS, 1980). The Committee on Nutrition of the American Academy of Pediatrics (Committee on Nutrition, American Academy of Pediatrics, 1976) suggests the intake for term infants, 4 months to 3 years, be 1 mg iron/kg body weight per day with a maximum intake of 15 mg/day; for low birth weight infants the recommendation is 2 mg/kg body weight per day with a maximum intake of 15 mg per day. The iron requirements of infants and children are as high or higher than those of adults. Thus, from these additional biochemical data, infants, children, women of child-bearing age, and possibly 11-14 year old males appear to constitute the "at risk" population.

Estimate of Available Iron Needed

Total iron intake, however, is not be the sole criterion for the assessment of proper iron nutriture. The amount of iron which can be absorbed must also be considered. Estimates of that needed to be absorbed to meet the needs of 80% to 90% of all women of child-bearing age vary from 1.3 mg to 2.2 mg iron daily, with a general consensus for need being approximately 1.5-1.8 mg per day or 0.7-0.9 mg/1000 kcal (Cole et al., 1972; Finch and Cook, 1984; Hallberg, 1981b; Monsen et al., 1978; WHO, 1975). The available iron needed by males and all non-menstruating females appears to be approximately 1.0 mg of iron per day (Hallberg, 1981b). Assuming about a 10% absorption rate, as is done with the dietary recommendations of three countries, for both adults and children, (Dallman et al., 1980; Health & Welfare, Canada, 1975; NAS, 1980; Dept. Health and Social Security - United Kingdom, 1969), an individual has available to them only about 0.6 mg of iron/1000 kcal, at an average intake of 6 mg per 1000 kcal. According to the U.S. Department of Agriculture, however, iron absorption rates average 6.5% to 8.7% (Riddick and Woteki, 1983). Therefore, absorbable iron that is available to the general population, would be closer to 0.78 mg to 1.04 mg iron/day or 0.39 mg to 0.52 mg per 1000 kcal, given a total dietary consumption of 6 mg iron per 1000 kcal. In one British study the amount of available iron consumed per day was estimated to be 0.8 mg iron/person (Bull and Buss, 1980). This was 6% to 7% of the

10.95 mg per day intake of total dietary iron. In one Canadian study the available iron intake for premenopausal women was reported to be 0.92 mg/day or 0.52 mg available iron/1000kcal (Gibson et al., 1984). For postmenopausal women the available iron intake was 1.28 mg/ day or 8.3 mg/1000 kcal (Gibson et al., 1984). This was a 7.6% absorption rate for premenopausal women and 10.9% absoprtion rate for postmenopausal women. Raper et al. (1984) showed that percent available iron ranged form 6.5% for 1-2 year-olds to 7.5% for 6-8 year-olds; 7.6% for 9-11 year-old females; 8.7% for 19-22 year-old males; 7.4% for 9-11 year-old females; and 8.2% for 19-22 and 35-64 year-old females. These studies appear to bear out the fact that the actual percent absorption rates for iron may be lower than the assumed figure of 10% used in establishing recommended allowances. Thus, average available iron intakes, in general population studies, appear to be overestimated by using a constant value as an estimate of available iron intake.

Food Frequency Studies

There are in fact many studies where the lack of a way to estimate available iron from total iron intake hinders the ability to give the true picture of iron nutriture. For example Farley et al. (1985) and Mahoney et al. (1985) have examined food frequency data collected fron 762 subjects aged 24 to 80 years in an attempt to determine the characteristics of diets which do actually provide adequate iron, (i.e. 9 mg of iron per 1000 kcal). Traditionally, it was thought that it is virtually impossible to consume 18 mg of iron through a conventional mix of food while consuming an adequate amount of calories (Bing, 1972). However, Farley et al. (1985) and Mahoney et al. (1985) concluded it is possible for a woman to consume the RDA for iron while maintaining her energy intake within suggested limits, given she makes proper food choices. The high iron dense diet reported by survey participants in the Mahoney et al. (1985) study consisted of larger portions of vegetables, fruits, cereal products, and thus met the need for total dietary iron. These authors did not, however, address the question of available iron. As a result, it remains unclear as to whether it is possible to consume adequate quantities of available iron using the same type of high iron dense food choices.

In other studies a food frequency methodology has also been used to answer pertinent questions with respect to iron such as the incidence of dietary iron less than the recommended allowances without signs of malnutrition (Darke et al., 1980); the iron nutriture of teenage girls in a low income area (Hertzler et al., 1976); dietary iron intake and nutrient supplementation in an elderly population (Gray et al., 1983). A food frequency methodology is often used because standard methods to evaluate the quality of a diet are tedious and time consuming (Crepin et al., 1982) and food frequency methodologies have records comparable to other survey instruments (Sorenson et al., 1985). Some investigators have tried to develop shorter methods by which total nutrient intake could be estimated from the frequency of ingestion of predictive food groups (Crepin et al, 1982; Hankin et al., 1968, Hankin et al., 1970, Hankin et al., 1978). Yet, in all these studies, only total iron intakes have been investigated. The question of available iron has not been addressed since there is no method to estimate available iron intake from total iron intake.

Studies which propose various patterns of "proper intake" based on information collected in the large national consumption surveys also deal with information collected as daily nutrient totals (Cleveland et al., 1983; Pennington, 1983; Peterkin et al., 1981). Examples of such studies would include those based on the Thrify Food Plan or on the Dietary Guidelines for Americans or on the Total Diet Plan (Cleveland et al., 1983; Pennington, 1983; Peterkin et al., 1981). If there were a model to estimate available iron based on total iron consumed, then these types of recommendations could also be developed with more concern toward the actual amounts of iron that are absorbed.

Time of Consumption

When dealing with a model to estimate available iron from totals of nutrients consumed an additional concern must be addressed. Simultaneous consumption of enhancement factors and the nonheme iron, in order to increase nonheme absorption, has been reported in the literature as being critical (Cook and Monsen, 1977). Data which are based on total nutrient intakes rather than on intakes recorded on a single meal basis, by their nature, do not take this factor of simultaneous consumption into account. Failure to do so may possibly have a confounding effect on the iron that is estimated to be available. Data from the Nationwide Food Consumption Survey (USDA, 1980) of 1977-78 reveal the average meal consumption, by percent, of the total daily intake of dietary ascorbic acid, iron, and protein to be as listed in Table 2 (USDA, 1980; Pao and Mickle, 1980):

Table 2. Percent distributions of ascorbic acid, total iron, and protein intakes, by meal, from the Nationwide Food Consumption Survey, (USDA, 1980; Pao and Mickle, 1980).

	Breakfast	Lunch	Dinner
Vitamin C	28.9%	28.3%	46.3%
Iron	25.1%	31.2%	48.0%
Protein	18.0%	33.8%	53.1%

Protein is included in Table 2 to give some indication of the consumption of meat, fish, poultry and the iron contained in those products. It should also be noted that these percents total to greater than 100%. The average consumption patterns of total meat iron, heme iron, and nonheme iron have not been published. However, it is this author's belief, that such information could form some type of average pattern of intake which gives percent consumption of the enhancement factors of nonheme iron: ascorbic acid, and meat, fish or poultry, for each meal and snack; and the average consumption patterns of total iron and meat iron, from which average patterns of heme and nonheme iron could be derived. This general consumption pattern could then be used to "correct" for the time of consumption factor (see the Methods section of Part II).

Summary

Infants, children, women of child-bearing age and possibly 11-14 year old males appear to constitute the "at risk" population for lower than needed intakes of total dietary iron. Available iron intakes also appear lower than needed for these "at risk" groups. However, in general population studies, available iron intakes appear to be overestimated by using a numerical constant to estimate the amount of iron absorbed. As a result, a valid estimate of available iron intake in this country is unclear.

Some studies have shown that the recommended intake of dietary iron can be consumed through proper food choices although it is still in question as to how much of that iron is available to be absorbed. Data based on daily nutrient totals, such as those from food frequency surveys, do give total dietary iron, but it is impossible to estimate available iron from such information.

Research on the three major factors which affect iron bioavailability has led to a model to estimate available iron (Monsen et al., 1978; Monsen and Balintfy, 1982). At present, this model has become the precedent for the estimation of available iron from intake data. However, this model can only be used with data recorded as meals consumed. Also, there are possible areas of concern with regard to the assumptions made in the formulation of the model. Thus, a model to estimate available iron based on totals of nutrients consumed is needed.

The time of consumption of the enhancement factors of nonheme iron absorption may be a significant factor in adapting a model for estimation of available iron. A pattern of average consumption of these enhancement factors may be useful in simulating "meals" from data recorded as daily totals of nutrients consumed rather than that recorded as meals eaten. This could then be used to estimate available iron from totals of nutrients consumed.

PART I

MEAL PATTERN OF AVAILABLE IRON; ASCORBIC ACID; AND MEAT, FISH, POULTRY INTAKES BY SCHOOL CHILDREN

Introduction

In recent years it has been shown that consumed iron forms two distinct "pools", known as heme and nonheme iron, differentiated by method of absorption (Clydesdale, 1983; Cook, 1983; Hallberg, 1981a; Morris, 1983). Nonheme iron is absorbed from a common mixture of iron formed when several food items are ingested simultaneously. Nonheme iron absorption can be either enhanced or inhibited by action of other food components on the solubility of the uncomplexed iron (Clydesdale, 1983; Cook, 1983; Hallberg, 1981a). The most potent enhancers of nonheme iron absorption appear to be ascorbic acid and meat (Cook, 1983; Hallberg, 1981a; Morris, 1983).

More heme iron than nonheme iron appears to be absorbed since heme iron is assimilated directly into the mucosal cells as an iron-porphyrin complex (Clydesdale, 1983; Cook, 1983). Heme iron absorption is generally considered not to be affected by other simultaneously ingested foods. These findings have been used to develop a model for the estimation of available iron (Monsen et al., 1978; Monsen and Balintfy, 1982). Available iron is assumed to be dietary iron that can be metabolized. Traditionally, however, dietary surveys of iron consumption have tended only to report average daily intake and little attention has been accorded to reporting available iron. Also, the consumption patterns of the factors employed in Monsen's model (Monsen et al., 1978; Monsen and Balintfy, 1982) for estimating available iron have not been extensively investigated. The purpose of this study was to provide information on the meal intake patterns of ascorbic acid; meat, fish, poultry; the iron contained in the grams of meat, fish, poultry consumed; and total iron intakes of school children.

Methods

The data used were collected in 1980 from written dietary questionnaires kept by 355 male and 382 female children, assisted by their parents, for two nonconsecutive weekdays. The children were from nine northern Utah schools, representing three districts (Hendricks et al., 1981). A registered dietitian confirmed the dietary data in the questionnaires by interviewing all the children, and their parents using, food models approximating common household measures. The questionnaires included space to record time of consumption, type of food or beverage consumed, amount consumed, and method of food preparation. Place of consumption was not recorded. Food items were coded and analyzed by computerized food composition tables which contain Handbook 8 (USDA, 1963b) nutrient data, and data for composite dishes/food items not found in Handbook 8 (USDA, 1963b). This information was used to quantify the nutrient intakes and grams of meat, fish, poultry consumed on a per meal and per snack basis; breakfast, morning snack, lunch, afternoon snack, dinner, and evening snack. The two-day totals of nutrients and grams of meat, fish, poultry consumed were averaged and then analyzed to obtain a mean percentage contribution of each of the nutrients; and meat, fish, poultry consumed, to total dietary intake, at each meal and snack (Table 3). Mean intake values of ascorbic acid; meat, fish, poultry; the iron contained in meat, fish, poultry; total iron; and total kcals consumed at breakfast, lunch, dinner, and snacks can be found in Table 4. Daily intakes of all variables presented in Tables 3 and 4 have also been broken down by sex and are recorded in the tables. Statistical comparisons between the sexes were not made in this analysis.

In Table 5 the amounts of heme iron (mg), nonheme iron (mg), available heme iron (mg), available nonheme iron (mg) and total available iron (mg), consumed per meal, were calculated using Monsen's assumptions (Monsen et al. 1978; Monsen and Balintfy, 1982). Heme iron was taken to be 40% of the total iron contained in all meat, fish, poultry items consumed at breakfast, lunch, dinner and all snacks. Nonheme iron was calculated as the difference between total iron and heme iron per each meal and snack. Available heme iron was considered to be 23% of the total heme iron. Available nonheme iron was calculated by multiplying total nonheme iron for each meal by the percent absorption factor

Table 3. Percent contribution of ascorbic acid; meat, fish, poultry; iron contained in meat, fish, poultry; and total dietary iron consumed per meal and snacks by Utah school children

Item	Break-fast %	Lunch %	Din-ner %	Snacks %	Mean Daily Intake
Vitamin. C	32.6	23.6	32.3	11.5[a]	90.3 mg
Std. dev.	0.25	0.20	0.22		65.4
Male[a]					93.9
Female					87.0
Meat, fish, poultry	3.5	36.9	53.6	5.2	86.7 g
Std. dev.	0.09	0.25	0.27		40.9
Male					89.4
Female					84.2
Meat Fe	3.4	35.2	55.3	5.4	2.4 mg
Std. dev.	0.09	0.26	0.29		1.3
Male					2.5
Female					2.4
Total Fe	29.3	28.3	33.5	8.9	11.6 mg
Std. dev.	0.14	0.12	0.13		4.4
Male					12.2
Female					11.0
Energy[a]	22.4	31.4	33.7	12.7	1781 kcal
Male					1866
Female					1702

[a]These values were obtained after the original computer programs were written. Therefore, it would have been necessary to rewrite the computer program to obtain standard deviations for these values.

Table 4. Mean consumption of ascorbic acid; meat, fish, poultry; iron contained in meat, fish, poultry; total iron and energy per meal by Utah school children[a]

Item	Breakfast	Lunch	Dinner	Snacks
Vitamin. C (mg)	32.8	19.1	26.3	12.2
Std. dev.	39.1	21.9	25.2	25.0
Meat, fish, poultry (g)	3.5	32.7	46.2	4.4
Std. dev.	9.9	24.1	28.5	13.2
Meat, Fish, Poultry Fe	0.09	0.87	1.34	0.12
Std. dev.	0.25	0.74	0.92	0.36
Fe (mg)	3.6	3.2	3.8	1.0
Std. dev.	3.2	1.7	2.2	1.3
Energy (kcal)	398	556	600	226
Std. dev.	173	215	264	243

[a]Constitutes mean consumption for 737 subjects.

as determined by the following equation proposed by Monsen and Balintfy (1982):

$$\% \text{ absorption} = 3 + 8.93 * \log_e \frac{(EF + 100)}{100};$$

where EF (enhancement factor) is equal to the mg of ascorbic acid consumed per meal plus the grams of meat, fish, and poultry consumed per meal, and individual iron stores are assumed to be 500 mg of iron.

Total available iron per meal was taken as the sum of the available heme iron for the meal in question, plus the available nonheme iron for the meal. The total available iron for each meal plus snacks determined the total daily available iron. These figures were used to determine the percent distribution of total available iron for the three meals and snacks. The figures for all food not consumed during breakfast, lunch, or dinner were combined to form the column titled "snacks" in each of the tables.

The percent distribution by meal of average heme iron intake, using actual heme iron values taken from the literature, rather than values derived as a percent of the meat iron consumed, as is done in Monsen's model (Monsen et al. 1978; Monsen and Balintfy, 1982), were also calculated. The actual heme iron values were taken from various sources (Hallberg, 1981b; Saffle, 1973; Schricker et al., 1982; Vahabzadeh, 1982).

Results and Discussion

To our knowledge the average consumption patterns of total iron, heme iron, nonheme iron, and the enhancement factors affecting nonheme iron absorption have not been published together. The overall intakes and meal distributions of ascorbic acid; meat, fish, and poultry; iron in meat, fish, poultry; total iron; and energy values for 5-11 year-old children are presented in Tables 3 and 4. Average intakes of iron and ascorbic acid exceeded RDA values for children 4-10 years of age (NAS, 1980). Recommended dietary caloric allowances for this age group are 1300-2300 kcal for 4-6 year-olds and 1650-3300 kcal for

7-10 year-olds (NAS, 1980). Thus, caloric intakes reported for this group of subjects do not appear, on the average, to be in excess nor deficit of the RDA (NAS, 1980). The intakes of total dietary iron and ascorbic acid were fairly evenly distributed among breakfast, lunch, and dinner; an average of 8.9 % of the iron and 11.5 % of the ascorbic acid were consumed at snacks. The percent of total dietary iron and ascorbic acid consumed in this study at the three meals and one snack compare well with those reported for adults in the USDA Nationwide Food Consumption Survey, Spring 1977, (USDA, 1980), although the percentages of the survey total to greater than 100%. The USDA (1980) reported 25.1%, 31.0%, 42.7% and 13.1% of the total daily intake of iron to be consumed at breakfast, lunch, dinner, and snacks, respectively, versus this study which shows 29.3%, 28.3%, 33.5% and 8.9% of the iron consumed at the three meals and one snack. The USDA (1980) also reported 30.7%, 25.0%. 40.4% and 15.0% of the total daily intake of ascorbic acid to be consumed at breakfast, lunch, dinner, and snacks, respectively, versus this study which indicates 32.6%, 23.6%, 32.3%, and 11.5% of the ascorbic acid consumed at the the three meals and one snack. The dinner and lunch meals were the major contributors of meat, fish, and poultry. Little iron from meat, fish, and poultry was consumed at breakfast and snacks. Totally, meat, fish, and poultry contributed 20.7% of the dietary iron in this study.

Available iron intakes based on large population groups have been published (Acosta et al., 1984; Bull and Buss, 1980; Gibson et al., 1984; Hallberg, 1981b; Raper et al., 1984). However, few studies have investigated the consumption of available iron by children. Raper et al. (1984) showed that percent available iron ranged from 6.5% for 1-2 year-olds to 7.5% for 6-8 year-olds; 7.6% for 9-11 year-old males, 8.7% for 19-22 year-old males; 7.4% for 9-11 year old females and 8.2% for 19-22 and 35-64 year old females. Bull and Buss (1980) reported an average available iron intake of 0.78 mg per person per day for entire families compared with a mean of 0.90 mg of available iron per child per day in this study (Table 5). Gibson et al. (1984) reported a calculated mean intake of available iron for premenopausal women of 0.92 mg/day; for postmenopausal women of 1.28 mg/day. Overall, the respective dietary iron and ascorbic acid densities in this study were 6.45 and 50.5 mg/1000 kcal. The available iron density was 0.50 mg/1000 kcal, for both males and females in this study, which was less than bioavailable iron densities calculated for typical Latin American diets (Acosta et al., 1984) and for Swedish diets (Hallberg, 1981b) but identical to the 0.50 mg per 1000 kcal reported by Raper et al. (1984) for 5-11 year-old children in the United States.

Meat, fish, poultry iron and heme iron intakes are presented in Tables 4 and 5. Heme iron was calculated based on the assumption that it represents 40% of the meat, fish,

Table 5. Mean consumption of heme iron, nonheme iron, available heme iron, available nonheme iron, total available iron, and percent distribution of total available iron consumption, by meal, for Utah school children[a]

Item	Breakfast	Lunch	Dinner	Snacks	Daily Intake
Heme Fe (mg)	0.04	0.35	0.54	0.05	0.97
Std. dev.	1.10	0.29	0.37	0.15	0.51
Male					1.00
Female					0.94
Nonheme Fe (mg)	3.56	2.85	3.28	0.96	10.64
Std. dev.	3.20	1.53	2.05	1.24	4.32
Male					11.23
Female					10.10
Available Heme Fe (mg)	0.01	0.08	0.12	0.01	0.22
Std. dev.	0.23	0.07	0.08	0.03	0.12
Male					0.23
Female					0.22
Available Nonheme (mg)	0.19	0.19	0.24	0.05	0.67
Std. dev.	0.20	0.12	0.17	0.08	0.31
Male					0.70
Female					0.63
Total Available Fe (mg)	0.20	0.27	0.36	0.06	0.90
Std. dev.	0.20	0.17	0.22	0.11	0.36
Male					0.93
Female					0.85
Available Fe, % distribution[b] (%)	21.1	30.7	42.5	5.7	100.0

[a]Calculated as previously described (Monsen et al. 1978; Monsen and Balintfy, 1982).

[b]Calculated with the original computer program and thus standard deviations are not reported.

poultry iron (Monsen et al., 1978). We also computed heme iron intake (0.78 $\pm$ 0.55 mg) using published actual heme values for meat, fish, and poultry (Hallberg, 1981b; Saffle, 1973; Schricker et al., 1982; Vahabzadeh, 1982). This heme iron value represents 6.8% of the total iron intake compared with 8.3% when it was assumed that 40% of the meat, fish, and poultry iron was heme iron. These values are lower than the general estimate that assumes heme represents 10-15% of the iron consumed in Western diets (Rossander et al., 1979; Hallberg, 1981b) and lower than the 10% of total iron that heme contributed to the diets of pre- and postmenopausal Canadian women (Gibson et al., 1984). However, these values are comparable to the 6%-12% range reported by Raper et al. (1984), as the contribution of heme iron to total iron intakes, and are also comparable to the estimate of Acosta et al. (1984) for Latin American diets.

This information then, as discussed in the preceding paragraphs, should aid in the formulation of general recommendations to help maximize iron availability. The absorption of nonheme iron can increase from 3% to 8%, depending upon the units of enhancement factor present at the particular meal (Monsen et al. 1978; Monsen and Balintfy, 1982). Therefore, increasing the consumption of enhancement factors at those meals that are richer in nonheme iron, as shown in Table 3, would increase the amount of available iron in the entire diet. Practical recommendations for the average individual include: 1) serving a ascorbic acid-rich food and/or consumption of meat, fish, poultry on a consistent basis at breakfast; and 2) consumption of meat, fish, poultry and/or a food or beverage high in vitamin C with snacks.

PART II

A MODEL TO ESTIMATE AVAILABLE IRON INTAKE FROM TOTAL IRON CONSUMED

Introduction

Factors which affect dietary iron bioavailability have been extensively investigated and this information reviewed (Clydesdale, 1983; Cook, 1983; Dallman et al., 1980; Finch and Cook, 1984; Hallberg, 1981a; Hallberg, 1981b; Morck et al., 1983; Morris, 1983). In general, the factors which appear to affect its absorption can be categorized as follows: the nature of the iron itself, other food components consumed simultaneously with the iron such as the enhancement/inhibitory factors of nonheme iron absorption, and the iron status of the individual. From these investigations several specific concepts were developed with regard to the nature of iron. It has been shown that dietary iron consists of two distinct "pools", known as heme and nonheme iron, differentiated by method of absorption (Clydesdale, 1983; Cook, 1983; Hallberg and Bjorn-Rasmussen, 1972; Hallberg, 1981a; Morris, 1983). Heme iron, derived mainly from the hemoglobin and myoglobin of meat products, constitutes 10%-15% of the iron consumed in Western diets (Hallberg, 1981b; Rossander et al., 1979). Heme iron is generally considered not to be affected by other simultaneously ingested foods (Hallberg, 1981b; Hussain et al., 1965; Layrisse et al., 1969). Nonheme iron is derived from foods of vegetable origin and also partially from meat. It constitutes the majority of the iron consumed in Western diets (Hallberg, 1981b; Rossander et al., 1979). Nonheme iron is absorbed from that common mixture of iron formed when several food items are ingested simultaneously. Ascorbic acid and the presence of meat, fish, poultry appear to enhance nonheme iron absorption (Clydesdale, 1983; Hallberg, 1981a; Morck et al., 1983; Morris, 1983; Rossander et al., 1979). The absorption of both heme and nonheme iron are influenced by the iron status of the individual in an inverse logarithmic manner (Finch and Cook, 1984; Hallberg, 1981a; Hallberg, 1981b; Monsen et al., 1978; Morris, 1983).

These findings have been used to develop a model for the estimation of available iron, which at present is the only model for the estimation of available iron (Monsen et al., 1978; Monsen and Balintfy, 1982). However, Monsen's model (Monsen et al. 1978; Monsen and Balintfy, 1982) can only be used with data that has been collected on a single meal basis. No model to estimate available iron from total iron intake has been presented in the literature. Bull and Buss (1980), in reporting average iron intakes of British households, estimated available iron based on total iron intake. This, however, was a modification of Monsen's model (Monsen et al. 1978; Monsen and Balintfy, 1982) and the results were not compared to those obtained using their procedure. Thus, it remains uncertain as to how the method of Bull and Buss compares with Monsen's model (Monsen et al. 1978; Monsen and Balinfty, 1982).

Cook and Monsen, in 1976, reported that 30%-40% of the iron in pork, liver, fish, and 50%-60% of the iron in beef, lamb, and chicken, are heme iron. Monsen et al. (1978) in proposing their model for the estimation of available iron, assumed 40% of the iron contained in a meat product to be heme iron. Recent estimates of the heme content of meat products, however, appear to vary (Hazell et al., 1978; Oellingrath and Slinde, 1985; Park et al., 1983; Schricker et al., 1982) and, on the average, appear to be greater than that estimated by Monsen et al. (1978) and by Cook and Monsen (1976). Data published by Schricker et.al. (1982) found the average amount of heme iron contained in pork, lamb, and beef to be 49%, 57% and 62% respectively, using an adaptation of the method used by Cook and Monsen (1976). Park et al. (1983), from a review of literature, estimated muscles from cows and steers contain 40%-80% of their iron as hemoglobin or myoglobin while Hazell et al. (1978) estimated that 70% of meat iron is pigment. Oellingrath and Slinde (1985) showed that the heme iron content of ground beef may be closer to 85%. They postulated that this may be due to the fact that heat was used by Cook and Monsen (1976) in the determination of heme iron content. It has previously been shown that heat or chemical processing can convert heme to nonheme iron through the oxidative cleavage of the porphyrin ring (Schricker and Miller, 1983) and this decreases the amount of heme iron present. However, estimates of the heme content of cooked meat products also appear to vary (Jansuittivechakul et al., 1985; Schricker and Miller, 1983). Data from Jansuittivechakul et al.

(1985) found that the heme iron content in raw meat, autoclaved meat, 5 minute boiled meat, 30 minute boiled meat, 90 minute boiled meat, rare baked meat, medium baked meat and well done baked meat was 58%, 21%, 53%, 43%, 38%, 56%, 47%, and 44% of total iron, respectively. These meats were shown to be of a similar iron bioavailabiltiy (Jansuittivechakul et al., 1985). Thus, it is conceivable that although the majority of meat consumed is cooked, the Monsen et al. (1978) estimate of heme iron content may be low, and that total available iron may be underestimated by this model.

The purposes of this study were: 1) to propose a model for the estimation of available iron from total daily nutrient intakes; and 2) to compare this model(s) with that of Monsen (Monsen et.al. 1978; Monsen and Balintfy, 1982), which uses data recorded on a per meal basis.

Methods

Introduction

In 1980 Utah State University and the Utah State Board of Education investigated Nutrition, Behavior and School Performance, (NBSP), (Hendricks et al., 1981). The nutrient data for this study were collected from written dietary questionnaires kept by 355 male and 382 female children, assisted by their parents, for two nonconsecutive weekdays.

The children were from nine northern Utah schools, representing three districts. A registered dietitian confirmed the dietary data in the questionnaires by interviewing all the children and their parents using food models approximating common household measures. Only those nutrients consumed dietarily were used in the calculations. Nutrients derived from supplementation were excluded from the calculations. The questionnaires included space to record time of consumption, type of food or beverage consumed, amount consumed, and method of food preparation. Place of consumption was not recorded. Food items were coded and analyzed by computerized food composition tables which contain Handbook 8 (USDA, 1963b) nutrient composition data as well as data for composite dishes and items not normally found in Handbook 8. This information was used to quantify the nutrient intakes and grams of meat, fish, poultry consumed.

In general the methods used in conducting this study consisted of: 1) the calculation, by computer, of available iron using Monsen's model (Monsen et al., 1978; Monsen and Balintfy, 1982) which estimates available iron from data collected on a per meal basis; 2) the calculation of three models, by computer, to estimate available iron intake from daily totals of iron consumed; and 3) statistical comparisons of the three calculated models to Monsen's model (Monsen et al., 1978; Monsen and Balintfy, 1982). The methods by which each model was calculated are described in succeeding paragraphs.

Monsen Model

The Monsen model (Monsen et al., 1978; Monsen and Balintfy, 1982) was used as a control model to which all other models were compared. The data of the Nutrition Behavior and School Performance (NBSP) data set (Hendricks et al., 1981) were recorded on a meal basis and thus, calculation of a control, using Monsen's model (Monsen et al., 1978; Monsen and Balintfy, 1982), could be performed. This involved the computation of the amounts of heme iron; nonheme iron; ascorbic acid; and meat, fish, or poultry consumed per person, per meal. Forty percent of the total iron in the meat, fish, poultry products consumed was considered to be the amount of total heme iron present for this control method. Twenty-three percent of the total heme iron present was considered absorbable and thus gave the figure for the available heme iron value. Total nonheme iron was the difference between total dietary iron and heme iron. The percent of nonheme iron considered available was based on the "units" of enhancement factor (EF) present and could range from 3% to 8%, with zero to 75 units present, respectively. A unit of EF was considered to be one milligram of ascorbic acid and/or one gram of meat, fish or poultry. The total units of EF were the sum of the milligrams of ascorbic acid plus the grams of meat, fish, or poultry, up to a total of 75 units. Thus, the actual percentage of available nonheme iron was calculated from the following equation developed from Monsen and Balintfy (1982):

$$\% \text{ absorption} = 3 + 8.93 * \log(n)\frac{(EF + 100)}{100}$$

Once both the amount of available nonheme iron and available heme iron were determined, they were summed to obtain the amount of available iron for each meal or snack. The subtotals for each meal or snack were then summed to determine total available iron intake for the day. This procedure was done for each subject.

One Large Meal

In this model, to be compared to the control it was assumed that the day's food was consumed as "one large meal" per individual. The analyses were run on the data as a unit, using the Monsen approach, (Monsen et al., 1978; Monsen and Balintfy, 1982) as outlined above, and all meals and snacks were treated as one summed meal.

The amount of enhancement factors used to determine the level of nonheme iron absorption was modified from that used in the Monsen protocol (Monsen et al., 1978; Monsen and Balintfy, 1982). Monsen's model (Monsen et al., 1978; Monsen and Balintfy, 1982) has an upper limit of 75 units of enhancement factor per meal but because the one large meal model (OLM) used total iron consumed to estimate available iron, a new method of determining the cut off point for the effect of enhancement factors was needed. As a result, it was decided that the total units of enhancement factors consumed per day would be divided by the following denominators: 1,3,4,5,6; and total available iron was calculated five separate times for the OLM model. These denominators are intended to represent an average number of meals eaten. These five separate models of the OLM model were then statistically compared with the control and all other proposed models.

The amount of heme iron present was computed in two ways: 1) assuming that 40% of the iron contained in the meat, fish, or poultry products consumed was heme iron; and 2) by using "actual heme iron" values obtained from the published literature for these products. The actual heme values were obtained from the literature or derived from information contained in the literature (Greenberg et al., 1957; Hallberg, 1981b; McDonald's System Inc., 1977; Monsen et al., 1978; Saffle, 1973; Schricker et al., 1982; USDA, 1963a; USDA, 1963b; USDA, 1974; Vahabzadeh, 1982). The heme iron values calculated using a figure of 40% of the meat iron are referred to in this paper as "calculated heme iron" whereas the heme iron values derived from the literature are referred as "actual heme iron" or "value derived heme iron". In this model then there were 10 different submodels for estimating total available iron (i.e. 5 means of calculating available iron * 2 ways to calculate heme iron = 10 total available iron values) which were calculated and tested.

<u>Bull and Buss</u>

The second of the proposed models used a method for the estimation of available iron reported by Bull and Buss (1980). This method relied heavily on Monsen's model (Monsen et al. 1978; Monsen and Balintfy, 1982) but was also similar to the one large meal concept in that the data were again treated as one summed unit, i.e. totals of nutrients consumed for the day. Also, the amount of heme iron present was again calculated in two ways as described previously; providing 2 submodels. The method used was as follows:

1. Totals for fortification iron were computed for each individual. Fortification iron was considered to be 11% of the total dietary iron consumed. It should be noted Bull and Buss (1980) used manufacturer's information concerning the amount of fortification iron contained in their products to arrive at the total amount of fortifcation iron consumed. However, their figures show this to be approximately 11% of the total iron consumed. Therefore, we used the 11% percent figure since actual manufacturer's information would be unavailable for use with daily nutrient totals which is the ultimate goal for use of this model.
2. Totals for dietary heme and nonheme iron were

computed for each individual. Sixty percent of the total iron in beef, lamb, other red meats, and poultry (referred to in the computer programming as type "a" or type "1" meat, fish, poultry) was considered to be heme iron, as was 40% percent of the iron in pork, bacon, ham, liver, and fish (referred to as type "b" or type "2" meat, fish, poultry). Nonheme iron was considered to be the difference between the amount of total iron computed and the amount of heme iron computed, minus the contribution of the fortification iron.

3. Available heme iron was considered to be 23% of the total amount of heme iron computed. Available nonheme iron was considered to be 5% of the total computed. Available fortification iron was taken as 1%, and as 5%, of the total computed, although the reason for this was not made clear by the authors (Bull and Buss, 1980).
4. The amounts of available heme, nonheme, and fortification iron were then summed to give the total amount of available iron.

General Consumption Pattern

The third proposed model consisted of: 1) the creation of a "general consumption pattern" (GCP) from the data, and 2) the use of this pattern to analyse the data. The GCP is percent amounts of total iron, total ascorbic acid, actual heme iron, total meat iron, and meat, fish, or poultry consumed, on the average, at breakfast, lunch, dinner, and snacks. The GCP was calculated by determining the percentages of the total of each of the above mentioned nutrients consumed, by each survey participant in the NBSP study (Hendricks et al., 1981), at the three meals and all snacks; and averaging these through use of a computer statistical package. All snacks were averaged into one general "snack". It should be noted that the nonheme iron and the calculated heme iron values are not included in the GCP because they can be calculated from the values derived from the GCP for meat iron and total iron minus heme iron, respectively. Heme iron was again calculated in two ways as described previously. The GCP which resulted was then used to analyse the NBSP data, now treated as daily totals of nutrients consumed. The totals of nutrients consumed were divided into three hypothetical "meals" and one "snack". Available iron was estimated using Monsen's model (Monsen et al. 1978; Monsen and Balintfy, 1982) on the hypothetical "meals".

Statistical Analysis

Statistical analysis was conducted using three separate computer oriented statistical packages. First, using the Minitab Statistical Package (Brigham Young University, 1985), the observed means (i.e. true means), standard deviations, medians, and ranges on the meal values generated by the GCP and the Monsen method (Monsen et al. 1978; Monsen and Balintfy, 1982) were obtained. Minitab was then used to obtain the true means, standard deviations, medians, and ranges on the daily totals of various nutrients consumed and the variables calculated by each of the models. Secondly, using the Rummage statistical package (Brigham Young University, 1983), the analysis of variance comparisons, broken down by sex and by density (i.e six cells), among the control and the three proposed models, as well as comparisons among the models themselves were run on five variables: total available iron, heme iron, nonheme iron, available heme iron and available nonheme iron. Actual iron density was recoded so that density 1, or new density 1, is equal to 0-5.99 mg Fe consumed per 1000 kcal, density 2 is equal to 6-8.99 mg Fe consumed per 1000 kcal, and density 3 is equal to 9-infinity mg Fe consumed per 1000 kcal. Finally, the SPSSX statistical package (SPSSX, 1983) was used to obtain the observed means on the 70 specific nutrients and other dietary components.

Due to subject number constraints, within the Rummage statistical package (Brigham Young University, 1983) itself, the Rummage procedures were run on only 451 of the original 737 subjects. The analysis on each variable (i.e. heme, nonheme, available nonheme, available heme and total available iron) was run on a different set of 451 randomly sampled subjects from the original 737 subjects. All other statistical procedures (i.e. the Minitab and SPSSX procedures) were run on the original 737 subjects.

Results and Discussion

Analyses of variance were run with the Rummage statistical package (Brigham Young University, 1983) on heme, available heme, nonheme, available nonheme, and total available iron broken down by sex, by new density, and by method. In the areas of analysis of density, sex, subject, method, and the interactions related to these areas it was determined that there were significant differences at the 0.05 level (Table 6). Areas of no significant difference appeared in the interactions of density by sex, sex by method, and density by sex by method (Table 6).

LSD Comparisons for Density, Sex, and Density by Sex for All Variables Analyzed

A summary of all possible least significant difference (LSD) comparisons within each area of analysis for density, sex, and density by sex for those variables with statistically significant F values was given in Table 7. Significant differences across the densities appeared for total available iron, nonheme iron and available nonheme iron. Significant differences appeared for density 1 (i.e. low iron density) versus density 2 (i.e. medium iron density) and density 2 versus density 3 (i.e. high iron density) for heme and available heme iron. No significant differences appeared for density 1 versus density 3 for heme

Table 6. Summary of analysis of variance results (Part II) (Alpha = 0.05).

Source	Total Available Fe	Heme Fe	Nonheme Fe	Available Nonheme Fe	Available Heme Fe
Density					
df/df	2/445	2/445	2/445	2/445	2/445
F (% prob[a])	31.6(0)	7.7(.1)	75.8(.1)	43.8(.1)	7.6(.1)
Sex					
df/df	1/445	1/445	1/445	1/445	1/445
F (% prob)	4.3(3.9)	0.9(3.5)	11.2(.1)	4.1(4.3)	0.85(3.6)
Density by sex					
df/df	2/445	2/445	2/445	2/445	2/445
F (% prob)	1.2(30.4)	0.7(48.9)	3.2(4.2)	8.6(42.3)	0.7(49.8)
Subject					
df/df	445/7120	445/2225	445/2670	445/6230	445/2225
F (% prob)	110.7(0)	30.7(0)	41.1(0)	68.9(0)	30.5(0)
Method					
df/df	16/7120	5/2225	6/2670	14/6230	5/2225
F (% prob)	1482.7(0)	276.9(0)	2987.4(0)	1563.0(0)	270.2(0)
Density by method					
df/df	16/7120	10/2225	12/2670	28/6230	10/2225
F (% prob)	59.8(0)	2.8(.2)	146.6(0)	60.7(0)	2.8(.2)
Sex by method					
df/df	16/7120	5/2225	6/2670	14/6230	5/2225
F (% prob)	2.3(.2)	0.5(78.6)	8.7(0)	2.5(.2)	0.5(77.9)
Density by sex by method					
df/df	32/7120	10/2225	12/2670	28/6230	10/2225
F (% prob)	1.4(6.9)	1.2(27.4)	0.8(69.8)	1.3(13.9)	1.2(27.6)

[a] % prob = percent probability

Table 7. Summary of density (D), sex (S), and density by sex (DS) LSD comparisons which were statistically significant (Sg) for total available iron (TAFE), heme iron (HEME), available heme iron (AV HEME), nonheme iron (NONHEME), and available nonheme iron (AV NONHEME) (Alpha = 0.05).[a]

Density Comparisons

	TAFE			HEME			AV. HEME			NONHEME			AV. NONHEME		
	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3	D1	D2	D3
D1		Sg	Sg		Sg	NS		Sg	NS		Sg	Sg		Sg	Sg
D2			Sg			Sg			Sg			Sg			Sg

Sex Comparisons - Male (M) vs Female (F)

	TAFE	HEME	AV. HEME	NONHEME	AV. NONHEME
	M	M	M	M	M
F	Sg	NS	NS	Sg	Sg

Density by Sex Comparisons

F tests for density by sex were not significant for all variables except nonheme iron. Below is a summary of those comparisons for nonheme iron.

	DS(1,M)	DS(2,M)	DS(3,M)	DS(1,F)	DS(2,F)	DS(3,F)
DS (1,M)		Sg	Sg			
DS (2,M)			Sg		NS	
DS (3,M)						NS
DS (1,F)				Sg		Sg
DS (2,F)						Sg
DS (3,F)						

[a] D1 or density 1 is 0-5.999 mg Fe consumed per 1000 kcal; D2 or density 2 is 6-8.999 mg Fe consumed per 1000 kcal. D3 or density 3 is 9-infinity mg Fe consumed per 1000 kcal. M = males; F = females. NS = nonsignificant.

and available heme iron. For sex, significant differences appeared for total available iron, nonheme iron and available nonheme iron but not for heme and available heme iron. Thus, it appears for the variables of total available iron, nonheme iron, and available nonheme iron there are significant differences among the densities and between the sexes. With regard to sex by density comparisons a significant F test appeared for nonheme iron only of all the variables analysed. A summary of the least significant difference comparisons made within the sex by density groupings for nonheme iron is found in Table 7.

LSD Comparisons for Method, Sex by Method, Density by Method for All Variables Analyzed

Analysis of variance among methods clearly show significant differences for all the variables analysed (Table 6). A summary of all LSD comparisons made against the control, or Monsen model (Monsen et al. 1978; Monsen and Balintfy, 1982), for those variables with significant F tests, within each area of analysis for method (Table 8), sex by method (Table 9), and density by method (Table 10), was made for each. A summary of all possible comparisons within each area of analysis was determined to be irrelevant in light of this project's objectives and thus was not included.

LSD comparisons of the methods (Table 8), for all variables, show no significant differences between the OLM

Table 8. Summary of method comparisons which were statistically nonsignificant (NS) when compared with the control (Monsen method) (Alpha = 0.05)[a].

Total Available Fe	Available Heme Fe	Heme Fe	Nonheme Fe	Available Nonheme Fe
One Large Meal Model, Calculated Heme Values				
TAFC012	AVHC02 NS	HMC02 NS	NHC02 NS	ANHC012
TAFC023				ANHC023
TAFC034 NS				ANHC034 NS
TAFC045				ANHC045
TAFC056				ANHC056
Bull & Buss Model, Calculated Heme Values				
TAFCB57	AVHCB3	HMCB3	NHCB3	ANHCB7
TAFCB18				
General Consumption Pattern Model, Calculated Heme Values				
TAFCG9 NS	AVHCG4 NS	HMGC4 NS	NHCG4 NS	ANHCG8 NS
One Large Meal Model, Heme Values Derived from the Literature				
TAVD0110	AVHVD05	HMVD05	NHVD05	ANHVD019
TAVD0211				ANVD0210
TAVD0312				ANVD0311 NS
TAVD0413				ANVD0412
TAVD0514				ANVD0513
Bull & Buss Model, Heme Values Derived from the Literature				
TAVDB15				ANVDB15 NS
TAVDB116			NHVDB6	
General Consumption Pattern Model, Heme Values Derived from the Literature				
TAFVDG17 NS	AVHVDG7	HMVDG7	NHVDG7 NS	ANHVDG15 NS

[a] The method used is implied in the abbreviations (see Appendix E).

Table 9. Summary of sex by method comparisons which were statistically nonsignificant (NS) as compared with the control (Alpha = 0.05)[a].

Total Available Fe	M	F	Available Heme Fe	M	F	Heme Fe	M	F	Nonheme Fe	M	F	Available Nonheme Fe	M	F
One Large Meal Model, Calculated Heme Values														
TAFC012			AVHC02			HMC02			NHC02	NS	NS	ANHC012		
TAFC023												ANHC023		
TAFC034	NS	NS										ANHC034	NS	
TAFC045												ANHC045		
TAFC056												ANHC056		
Bull & Buss Model, Calculated Heme Values														
TAFCB57			AVHCB3			HMCB3			NHCB3			ANHCB7		
TAFCB18														
General Consumption Pattern Model, Calculated Heme Values														
TAFCG9	NS	NS	AVHCG4			HMGC4			NHCG4			ANHCG8	NS	NS
One Large Meal Model, Value Derived Heme Values														
TAVD0110			AVHVD05			HMVD05			NHVD05	NS	NS	ANHVD019		
TAVD0211												ANVD0210		
TAVD0312	NS											ANVD0311	NS	NS
TAVD0413												ANVD0412		
TAVD0514												ANVD0513		
Bull & Buss Model, Value Derived Heme Values														
TAVDB15												ANVDB14	NS	NS
TAVDB116									NHVDB6					
General Consumption Pattern Model, Value Derived Heme Values														
TAFVDG17	NS	NS	AVHVDG7			HMVDG7			NHVDG7	NS	NS	ANHVDG15		

[a] For method used see Appendix E. Blanks = significance. M = males. F = females.

Table 10. Summary of density by method comparisons which were statistically nonsignificant (NS) when compared with the control (Alpha = 0.05)[a].

Total Available Fe				Available Heme Fe				Heme Fe				Nonheme Fe				Available Nonheme Fe			
One Large Meal Model, Calculated Heme Values																			
	D1	D2	D3		D1	D2	D3		D1	D2	D3		D1	D2	D3		D1	D2	D3
TAFC012				AVHC02	NS	NS	NS	HMC02	NS	NS	NS	NHC02	NS	NS	NS	ANHC012			
TAFC023																ANHC023			
TAFC034	NS	NS	NS													ANHC034	NS	NS	
TAFC045																ANHC045			
TAFC056																ANHC056			
Bull & Buss Model, Calculated Heme Values																			
TAFCB57				AVHCB3				HMCB3				NHCB3				ANHCB7			
TAFCB18																			
General Consumption Pattern Model, Calculated Heme Values																			
TAFCG9	NS	NS	NS	AVHCG4	NS	NS	NS	HMGC4	NS	NS	NS	NHCG4				ANHCG8	NS	NS	NS
One Large Meal Model, Heme Values Derived from the Literature																			
TAVD0110				AVHVD05				HMVD05				NHVD05	NS	NS	NS	ANHVD019			
TAVD0211																ANVD0210			
TAVD0312	NS	NS														ANV0311	NS	NS	NS
TAVD0413																ANVD0412			
TAVD0514																ANVD0513			
Bull & Buss Model, Heme Values Derived from the Literature																			
TAVDB15																ANVDB14	NS	NS	NS
TAVDB116												NHVDB6							
General Consumption Pattern Model, Value Derived Heme Values																			
TAFVDG17	NS	NS		AVHVDG7				HMVDG7				NHVDG7	NS	NS	NS	ANHVDG15			

[a] For method used see Appendix E. Blanks = statistical significance.

model using calculated heme values, the GCP using calculated heme values, and the GCP using actual (value derived) heme values when compared with the Monsen model (Monsen et al. 1978; Monsen and Balintfy, 1982) for total available iron, nonheme iron, and available nonheme iron. This also holds true for the LSD comparison of the OLM model using actual (or value derived) heme values when compared with the Monsen model (Monsen et al. 1978; Monsen and Balintfy, 1982), for available nonheme iron. It should be noted that with regard to total available iron and available nonheme iron the LSD comparison which appeared nonsignificant was the OLM model with enhancement factors divided by "4".

LSD comparisons of the methods (Table 8) show no significant differences between the OLM model using calculated heme values, and the GCP using calculated heme values, when compared with the Monsen model (Monsen et al. 1978; Monsen and Balintfy, 1982) for heme iron and available heme iron.

It can be concluded from Tables 8, 9, 10 that the models which appear to have no significant differences from the Monsen method (Monsen et al. 1978; Monsen and Balintfy, 1982), that is those which predict similar amounts of heme, nonheme, available heme, available nonheme, total available iron are: 1) the OLM model using calculated heme values; 2) the GCP model using calculated heme values; 3) the OLM model using actual (or value derived) heme values; and 4) the GCP model using actual (or value derived) heme values, for those areas of analysis with significant F tests, (i.e. method, sex by method, density by method). It should be noted that the OLM model, using calculated heme values, varies slightly for the each variable analyzed (i.e. heme iron, available heme iron etc.), because of the methodology with regard to enhancement factors . Although at least one of the OLM models, using calculated heme values, showed no significant difference for each variable analysed, the particular OLM model which showed no significant difference varied (i.e. it varied in the amount by which the enhancement factors were divided) when analyzing total available iron and available nonheme iron. The OLM model methodology, using calculated heme values, does not take into consideration the enhancement factor effect for available heme, heme, and nonheme iron variables.

Discussion of Method LSD Comparisons for Total Available Iron

The OLM model with enhancement factors divided by 4 using calculated heme values, the GCP using calculated heme values, the OLM model with enhancement factors divided by 4 using actual heme values, and the GCP using actual heme values, were the methods in this study which yielded predicted values for total available iron, which were not significantly different from the Monsen model (Monsen et al. 1978; Monsen and Balintfy, 1982). The observed means for total available iron predicted from these methods are given in Table 11. The observed means for two methods which predicted significantly higher values from Monsen's model (Monsen et al. 1978; Monsen and Balintfy, 1982) are also given. These are the OLM model with enhancement factors divided by 1 using calculated heme values and the OLM model with enhancement factors divided by 1 using actual heme values. As can be seen in Table 11 the total available iron values of the four methods determined to be not significantly different from Monsen's method (Monsen et al. 1978; Monsen and Balintfy, 1982), are also similar across iron densities in estimation of total available iron to that estimated by the Monsen model (Monsen et al. 1978; Monsen and Balintfy, 1982). Thus, total iron intake does not appear to interfere with these models' ability to estimate total available iron. The two significantly different methods consistently predict higher estimates of available iron from the Monsen model (Monsen et al. 1978; Monsen and Balintfy, 1982), across the iron density categories.

The OLM model with enhancement factors divided by 3 using calculated heme values and the OLM model with enhancement factors divided by 3 using actual heme values (Table 12) also predicted significantly higher values than the Monsen model (Monsen et al. 1978; Monsen and Balintfy, 1982) but are not included in Table 11. It can be assumed, that if calculated, the OLM model with enhancement factors divided by 2, using calculated heme values, and the OLM model with enhancement factors divided by 2, using actual

Table 11. Comparison of the observed means for total available iron of those methods which were not significantly different from the control and those methods which predicted signficantly higher values[a].

Density	I (0-5.999 mg Fe/1000 kcal)		II (6-8.999 mg Fe/1000 kcal)		III (9-Inf. mg Fe/1000 kcal)		Entire Population		
Sex	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Both
N	165	176	155	172	35	34	355	382	737
Monsen	0.82	0.70	0.95	0.90	1.35	1.36	0.93	0.85	0.89
Nonsignificant methods:									
OLM, calc'd, EF/4	0.84	0.69	0.97	0.91	1.36	1.36	0.95	0.85	0.90
GCP, calc'd	0.83	0.70	0.97	0.91	1.39	1.37	0.95	0.85	0.90
OLM, actual, EF/4	0.81	0.65	0.95	0.88	1.32	1.33	0.92	0.81	0.87
GCP, actual	0.80	0.66	0.95	0.88	1.35	1.35	0.92	0.82	0.87
Significant methods:									
OLM, calc'd, EF/1	1.39	1.14	1.64	1.52	2.40	2.40	1.60	1.42	1.51
OLM, actual, EF/1	1.37	1.11	1.62	1.50	2.38	2.39	1.58	1.40	1.50

[a] "OLM" = one large meal model. "Calc'd" = heme values derived as a percent of total iron. "EF" = enhancement factors. "GCP" = general consumption pattern. "Actual" = heme values derived from the literature.

Table 12. Comparison of the observed means by sex and by density for total available iron for all methods[a].

Density	I (0-5.999 mg Fe/1000 kcal)		II (6-8.999 mg Fe/1000 kcal)		III (9-Inf. mg Fe/1000 kcal)		Entire Population		
Sex	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Both
N	165	176	155	172	35	34	355	382	737
TAFM1	0.82	0.70	0.95	0.90	1.35	1.36	0.93	0.85	0.89
TAFC012	1.39	1.14	1.64	1.52	2.40	2.40	1.60	1.42	1.51
TAFC023	0.92	0.76	1.08	1.00	1.51	1.51	1.05	0.94	0.99
TAFC034	0.84	0.69	0.97	0.91	1.36	1.36	0.95	0.85	0.90
TAFC045	0.78	0.65	0.91	0.85	1.26	1.25	0.88	0.79	0.84
TAFC056	0.74	0.62	0.86	0.81	1.18	1.18	0.84	0.75	0.79
TAFCB57	0.76	0.65	0.88	0.83	1.21	1.18	0.86	0.78	0.82
TAFCB18	0.72	0.61	0.82	0.78	1.13	1.09	0.80	0.73	0.77
TAFCG9	0.83	0.70	0.97	0.91	1.39	1.38	0.95	0.86	0.90
TAVD0110	1.37	1.11	1.62	1.50	2.40	2.40	1.58	1.40	1.50
TAVD0211	0.89	0.72	1.05	0.98	1.48	1.49	1.02	0.90	0.96
TAVD0312	0.81	0.65	0.95	0.88	1.32	1.33	0.92	0.81	0.87
TAVD0413	0.75	0.60	0.89	0.82	1.22	1.23	0.86	0.76	0.81
TAVD0514	0.71	0.57	0.84	0.78	1.15	1.15	0.81	0.72	0.76
TAVDB15	0.67	0.56	0.78	0.73	1.13	1.09	0.76	0.68	0.72
TAVDB116	0.62	0.52	0.73	0.68	1.04	1.00	0.71	0.64	0.67
TAFVDG17	0.81	0.66	0.95	0.88	1.35	1.35	0.92	0.82	0.87

[a] For method used see Appendix E.

heme values, would also predict higher values than the Monsen model (Monsen et al. 1978; Monsen and Balintfy, 1982). However, this model (i.e. the OLM model with enhancement factors divided by 2) was not computed in this study.

Thus, from this data set, it can be concluded that the GCP and the OLM model, with enhancement factors divided by "4", can predict total available iron comparable to that predicted by the Monsen model (Monsen et al. 1978; Monsen and Balintfy, 1982), whether using calculated heme values or "actual" heme values (i.e values derived from the literature). Both then are possible alternatives for estimating available iron and can be used on data recorded as daily totals of nutrients consumed. The fact that the enhancement factors employed in the OLM model must be modified, namely that the enhancement factors must be divided by "4", to compare well with the Monsen model (Monsen et al. 1978; Monsen and Balintfy, 1982) may be an anomaly that applies only to this data set. In addition, the fact that the GCP was derived from the data on which it was also used to determine total available iron may present some problems in extrapolation to other data sets. However, the simplicity of the OLM model coupled with the usefulness of such a model, for data recorded as totals of nutrients consumed, warrants consideration of this proposal. Such a method could more easily be used to give general population estimates of available iron intake from intake data concerning total iron consumed.

In Table 12 the observed means for all methods used to predict total available iron are given for all iron densities. In Table 8 and Table 12 it can be shown that the method of Bull and Buss (1980) predicted significantly lower values for total available iron (See Table 12 for methods: TAFCB57, TAFCB18, TAVDB515, TAVDB116) than the Monsen model (Monsen et al. 1978; Monsen and Balintfy, 1982) for this data set. From this information it could be argued that Bull and Buss (1980) underestimated the total available iron intake of British households and that their method for estimating total available iron from totals of nutrients consumed does not compare well with that of Monsen's (Monsen et al. 1978; Monsen and Balintfy, 1982).

Higher Estimates of Total Available Iron

Some questions as to the Monsen's assumptions (Monsen et al. 1978; Monsen and Balintfy, 1982) in estimating total available iron intake from single meals have been reviewed earlier in this paper. It was suggested that because heme iron values may be underestimated in the Monsen model (Monsen et al. 1978; Monsen and Balintfy, 1982), estimates of total available iron consumption may also be underestimated by this model. Population studies tend to bear this out (Acosta et al., 1984; Bull and Buss, 1980;

Gibson et al., 1984; Hallberg, 1981b; Raper et al., 1984; Valberg et al., 1976). The available iron needed by premenopausal women appears to vary from 1.3 mg to 2.2 mg per day with the general consensus for need being approximately 1.5 mg-1.8 mg of available iron per day (Cole et al., 1972; WHO, 1975; Monsen et al., 1978; Hallberg, 1981b; Finch and Cook, 1984). The available iron needed by males and all non-menstrating females appears to be approximately 1.0 mg of iron per day (Hallberg, 1981b; Finch and Cook, 1984).

Studies, based on large population groups, report available iron intakes which, on the average, are less than that which appears to be needed (Bull and Buss, 1980; Gibson et al., 1984; Raper et al., 1984). Bull and Buss (1980) reported an average available iron intake of 0.78 mg per person per day for entire families. Gibson et al. (1984) reported a mean intake of available iron for premenopausal women of 0.92 mg/day; for postmenopausal women of 1.28 mg/day. Raper et al. (1984) published available iron intakes for 1-8 year-olds of 0.50 mg to 0.80 mg per day; for 9-75 year-old males of 0.95 mg to 1.39 mg per day; 9-75 year-old females of 0.73 mg to 0.86 mg per day. All studies used the Monsen method (Monsen et al. 1978; Monsen and Balintfy, 1982), or a modification thereof, to determine available iron intakes.

In addition, Gibson et al. (1984) suggested that 73% of the premenopausal women in their study would fail to meet the average Canadian requirement for absorbed iron (i.e. 1.12 mg). However, contrasting this to the findings of Valberg et al. (1976), Gibson et al. (1984) concluded that the Monsen model (Monsen et al. 1978; Monsen and Balintfy, 1982) overestimates the number of premenopausal women with insufficient available iron intakes. Valberg et al. (1976), using serum ferritins, found that only 30% of randomly sampled, premenopausal, Canadian women were iron deplete.

Finally, it should be noted that the OLM model with enhancement factors divided by 1 and 3, respectively, both estimated higher total available iron intakes (Table 11) than the Monsen model (Monsen et al. 1978; Monsen and Balintfy, 1982). These predicted average iron values are similar to that needed, by women, as described previously. Obviously further research in which actual available iron intakes are compared to those estimated by the various models, must be done. However, the fact remains that the OLM model, with enhancement factors divided by 4, and the GCP model could be used as adequate substitutes for the Monsen model (Monsen et al., 1978; Monsen and Balintfy, 1982) in estimating total available iron. Also, the OLM model with enhancement factors divided by 1 or 3, or possibly 2, could be used in estimating higher intakes of available iron.

Time of Consumption

The fact that the estimated total available iron values of the OLM model and of the GCP model showed no significant differences when compared with those of the Monsen model (Monsen, et al. 1978; Monsen and Balintfy, 1982) also raises questions as to the importance of the time of consumption of the enhancement factors of nonheme iron absorption. Estimates which are based on total nutrient intakes rather than on intakes recorded as a single meal, by their nature, do not take this time of simultaneous consumption into account. Simultaneous consumption of the enhancement factors and nonheme iron in order to increase absorption, has been reported and implied in the literature as being critical (Cook and Monsen, 1977, Monsen et al., 1978). However, the effects of the enhancement factors appear to be able to be accounted for by a correction factor, representing the average number of meals eaten, as is done in the OLM model and by assuming a common pattern of consumption, as is done in the GCP model. Thus, from this study, consideration of the effects of enhancement factors with regard to nonheme iron absorption, on a per meal basis, appears to be unnecessary.

PART III

AVAILABLE IRON INTAKES OF SCHOOL CHILDREN CONSUMING HIGH IRON DENSITY DIETS

Introduction

The highest Recommended Dietary Allowance (RDA) for iron in the United States is in the following age categories: females 11-14, 15-18, 23 to 50 years, and males 11-14, 15-18 years (NAS, 1980). The allowance is 18 mg of iron per day. This allowance expressed in terms of mg of iron recommended per 1000 kcal of suggested energy intake (nutrient density), for the categories females 11-14, 15-18, 19-22, 23-50 years, males, 11-14, 15-18 years is 8.2 mg, 8.6 mg, 8.6 mg, 9.0 mg, 6.7 mg, 6.4 mg, respectively (Hansen and Wyse, 1980; NAS, 1980).

The average American consumes only 6-7 mg of iron per 1000 kcal. This has been shown for women (USDA, 1980; USDHHS, 1983; Pao, 1981), for children (USDA, 1980; USDHEW-Ten State Nutrition Survey, 1970), and for men (USDA, 1980; Richard and Roberge, 1982). From those groups with the highest iron requirement it appears only women 12 to 50 years consistently consume less total iron, per 1000 kcal than recommended, given the average American consumption of 6-7 mg daily per 1000 kcal. However, biochemical data from NHANES II (Expert Scientific Working Group, 1985) show a relatively high prevalence of low iron status in children, 1-2 years of age; 11-14 year old males. For infants and children age 6 months to 3 years the USRDA is 15 mg of iron per day (NAS, 1980). The iron density for 1-3 year olds given the average suggested energy intake is 11.5 mg iron per 1000 kcal (Hansen, 1980; NAS, 1980). Thus infants, small children, women of child-bearing age and possibly 11-14 year old males appear to constitute the "at risk" population for iron deficiency in this country.

Farley et al. (1985) and Mahoney et al. (1985) have examined food frequency data collected from 762 subjects, aged 24 to 80 years, in an attempt to determine the characteristics of diets which do actually provide a high-iron dense diet, i.e. 9 mg of iron per 1000 kcal. Traditionally, it was thought that it is virtually impossible to consume 18 mg of iron through a conventional mix of food while consuming an adequate amount of calories (Bing, 1972). However, Farley et al. (1985) and Mahoney et al. (1985) concluded it is possible for a woman to consume the RDA for iron while maintaining her energy intake within suggested limits, given she makes proper food choices. The high-iron dense diet reported by survey participants in Mahoney's study consisted of larger portions of vegetables, fruits, cereal products and thus met the need for total dietary iron.

The purpose of this study was to examine in school children total available iron intakes when consuming high-iron dense diets.

Methods

For two nonconsecutive weekdays, in 1980, written dietary questionnaires were kept by 355 male and 382 female children, average age 7.5 years, from nine northern Utah schools, representing three districts (Hendricks et al., 1981). Assisted by their parents, dietary information concerning time of consumption, type of food or beverage consumed, amount consumed, and method of food preparation were recorded by the children. Using food models, approximating common household measures, registered dietitians confirmed the information in the questionnaires by personal interview with the children and their parents. Only that information concerning intakes from food were analyzed for this study. Food items were then coded and analyzed by computerized food composition tables which contained USDA Handbook 8 (1963b) nutrient composition data as well as data for composite dishes and items not found in Handbook 8.

Following the design of Farley et al. (1985) and Mahoney et al. (1985), survey participants were categorized into three levels of iron intake based on iron density: density 1, 0-5.99 mg Fe consumed per 1000 kcal; density 2, 6-8.99 mg Fe consumed per 1000 kcal; and density 3, 9-infinity mg Fe consumed per 1000 kcal. Analysis of variance procedures and least significant difference comparisons were run on the estimated means of the following nutrients: energy, protein, fat, carbohydrate, crude fiber, iron, and vitamin C. Analysis of variance procedures and least significant difference comparisons were also run on the estimated means of the following dietary components: grams of meat, fish, poultry; mg of iron contained in the meat, fish, poultry consumed; amount of heme iron, derived from actual heme values found in the literature; amount of total available iron, as calculated by the method of Monsen (Monsen et al., 1978; Monsen and Balintfy, 1982); the amount of heme iron consumed, derived as a percent (i.e. 40%) of the iron contained in meat, fish, poultry as is done in the Monsen method (Monsen et al., 1978; Monsen and Balintfy, 1982); and the amount of nonheme iron consumed, as described in the Monsen method (Monsen et al., 1978; Monsen and Balintfy, 1982). Monsen's method to estimate total available iron is described elsewhere (Monsen et al. 1978; Monsen and Balintfy, 1982). The "actual" heme iron figures, derived from published values, were taken from various sources (Hallberg, 1981b; Saffle, 1973; Schricker et al., 1982; Vahabzadeh, 1982). Student's T tests were run on the estimated means for iron density between the sexes for each density category. The heme iron values calculated using a figure of 40% of the meat iron (Monsen et al., 1978; Monsen and Balintfy, 1982) are referred to in this paper as "calculated heme iron" whereas the heme iron values derived from the literature are referred as "actual heme iron" or "value derived heme iron".

Results and Discussion

Analysis of variance and least significant difference comparisons were run on 13 nutrients and other dietary components, as described above. The observed means of these nutrients and dietary components, broken down by sex, and by density categories, are presented in Table 13. Values with the same superscript on the same line in Table 13 were determined not to be significantly different for the particular nutrient or dietary component in question. The observed means of the nutrients and other dietary components consumed, broken down by sex, and by density categories, for the entire population are presented in Table 14. Values with the same superscript show sex effects which were nonsignificant. A summary of the overall analysis of variance results are given in Table 15.

The Recommended Dietary Allowance for iron, as expressed in terms of nutrient density, is 5.9 mg iron per 1000 kcal for children 4-6 years and 4.2 mg iron per 1000 kcal for children 7-10 years (Hansen and Wyse, 1980, NAS, 1980). In this study the mean iron densities for males in the three iron density groups were 5.3 mg, 6.9 mg, 12.0 mg, respectively (Table 13). The mean iron densities for females in the three iron density groups were 5.2 mg, 6.9 mg, 11.5 mg, respectively (Table 13). The mean iron densities, by sex, meet the RDA, as expressed in terms of iron consumed per 1000 kcal of suggested energy intake, for

Table 13. Observed means of selected nutrients and other dietary components by sex and by density^{x}.

Density	I (0-5.999 mg Fe/1000 kcal)		II (6-8.999 mg Fe/1000 kcal)		III (9-Inf. mg Fe/1000 kcal)	
Sex	Boys	Girls	Boys	Girls	Boys	Girls
N	165	176	155	172	35	34
Energy (kcal)	1972^{d}	1752^{ab}	1792^{a}	1656^{ac}	1690^{bc}	1669^{abc}
Protein (g)	72.2^{a}	63.7^{b}	70.8^{a}	64.5^{b}	64.5^{b}	64.5^{b}
Fat (g)	84.9^{d}	75.9^{c}	73.4^{bc}	69.0^{b}	62.2^{a}	63.1^{a}
CHO (g)	236.7^{a}	209.3^{bd}	219.2^{bc}	199.9^{d}	226.9^{ac}	220.6^{bc}
Crude fiber (g)	3.0^{a}	2.6^{b}	3.5^{c}	3.1^{a}	3.9^{d}	3.6^{c}
Total Fe (mg)	10.4	9.1	12.3	11.4	20.3	19.2
Iron Density (mg/1000 kcal)	5.3^{a}	5.2^{a}	6.9^{b}	6.9^{b}	12.0^{c}	11.5^{c}
Vitamin C (mg)	93.8^{a}	81.1^{b}	95.2^{a}	91.4^{a}	88.4^{ab}	95.3^{a}
Meat, fish, poultry (g)	92.3^{a}	76.7^{b}	91.4^{a}	92.6^{a}	67.2^{c}	80.0^{b}
Meat, fish, poultry iron (mg)	2.5^{a}	2.1^{b}	2.6^{ac}	2.7^{c}	2.1^{b}	2.2^{b}
Actual heme (mg)	0.81^{ad}	0.57^{b}	0.92^{c}	0.91^{cd}	0.62^{be}	0.72^{ae}
Avail. Fe (mg)	0.82	0.70	0.95	0.90	1.34^{a}	1.36^{a}
Cal. heme (mg)	0.98^{a}	0.82^{c}	1.05^{ab}	1.07^{b}	0.82^{c}	0.87^{d}
Nonheme Fe (mg)	9.4	8.3	11.3	10.3	19.5	18.3

^{x}Values with the same superscript are not significantly different from those values on the same line. "Actual" heme is derived from published values. "Calculated" heme (Cal. heme) iron is taken as a percent of the meat, fish, poultry iron consumed. Iron density only was analyzed by student's T test.

Table 14. Observed means of selected nutrients and other dietary components, by sex, and by density, for the entire population[x].

Density	Entire Population		
Sex	Boys	Girls	Both
N	355	382	737
Energy (kcal)	1866	1702	1781
Protein (g)	70.8	64.1	67.4
Fat (g)	77.6	71.7	74.5
CHO (g)	228.1	206.1	216.7
Crude Fiber (g)	3.3	2.9	3.1
Total Fe (mg)	12.2	11.0	11.6
Iron Density (mg/1000 kcal)	6.7[z]	6.5[z]	6.6
Vitamin C (mg)	93.9[z]	87.0[z]	90.3
Meat, fish, poultry (g)	89.4[z]	84.2[z]	86.7
Meat, fish, poultry iron (mg)	2.5[z]	2.4[z]	2.4
Actual heme (mg)	0.84	0.73	0.79
Available Fe (mg)	0.93[z]	0.85[z]	0.89
Calculated heme Fe (mg)	0.99[z]	0.94[z]	0.97
Nonheme Fe (mg)	11.2	10.1	10.6

[z] Sex effects are non-significant for that nutrient or other dietary component.

[x] Iron density only was analyzed by student's T test.

Table 15. Summary of analysis of variance results (Part III).

Source of Variation	Sex	Density	Sex by Density
df/df	1/731	2/730	2/730
Energy			
F (%, prob[a])	8.1 (0.4)	9.4 (0.0)	1.6 (19.8)
Protein			
F (%, prob)	7.0 (0.8)	0.9 (39.9)	1.4 (25.0)
Fat			
F (%, prob)	3.1 (7.7)	21.0 (0.0)	1.5 (22.9)
Carbohydrate			
F (%, prob)	8.8 (0.3)	4.3 (1.4)	0.9 (39.1)
Crude fiber			
F (%, prob)	8.0 (0.5)	18.0 (0.0)	0.1 (90.2)
Total iron			
F (%, prob)	11.7 (0.1)	244.5 (0.0)	0.3 (77.8)
Vitamin C			
F (%, prob)	0.3 (65.8)	0.7 (51.1)	0.8 (44.2)
Meat, fish, poultry			
F (%, prob)	0.2 (89.5)	7.0 (0.1)	5.6 (0.4)
Meat, fish, poultry Fe			
F (%, prob)	0.3 (56.8)	10.6 (0.0)	3.0 (5.1)
Actual heme Fe			
F (%, prob)	1.1 (29.8)	18.0 (0.0)	5.6 (0.4)
Available Fe			
F (%, prob)	3.1 (7.7)	105.2 (0.0)	1.9 (14.6)
Calculated heme Fe			
F (%, prob)	0.3 (56.2)	10.6 (0.0)	3.0 (5.1)
Iron density[b]	0.9		

[a] (%, prob) = percent probability.

[b] Independent variable analyzed with student's T test; analyzed only for the sex effect of the entire population.

each of the density categories. Survey data indicate the average American consumes 6-7 mg of iron per 1000 kcal (USDA, 1980; USDHHS, 1983; Pao, 1981; Raper et al., 1984; Richard and Roberge, 1982; USDHEW-Ten-State Nutrition Survey, 1970). Thus, it appears the average child in this study meets the RDA for iron, as expressed in terms of iron density. Iron intake for for each child appears consistent with that of the nation as a whole.

There were no statistically significant differences among the girls, across iron density categories, for the amounts of energy, protein, and vitamin C consumed. Also, with regard to the amounts of energy consumed, there were no statistically significant differences between boys and girls in category 2, or in category 3. The boys in category 1 consumed significantly higher amounts of energy than any other group, both boys and girls, in any density category. Boys in categories 1 and 2 consumed significantly higher amounts of protein while boys in categories 1 and 3 consumed significantly higher amounts of vitamin C than the other groups. Total available iron consumption is significantly different between the sexes and between the categories for densities 1 and 2 while in density 3 there are no significant differences between the sexes. No discernable patterns of intake for carbohydrate, crude fiber, grams of meat, fish, poultry consumed, the iron contained in the meat, fish, poultry consumed, the amounts of "actual" heme or "calculated" heme consumed can be made from these least significant difference comparisons.

If the nutrients and other dietary components consumed by both sexes were averaged within each iron density category, several additional observations can be made. The mean calories consumed would be 1858, 1720, and 1679 for density 1, 2, and 3, respectively, while the mean fat intake would be 80.3g, 71.1g, and 62.6g for the three densities, respectively. The percent of energy consumed as fat, then, for density 1, 2, 3 and both sexes is 39%, 37% and 33%, respectively. Again averaging the nutrients consumed by both sexes, within density categories, mean intakes of crude fiber for density groups 1, 2, and 3 would be 2.8g, 3.3g, and 3.7g, respectively. Thus, it can be concluded the boys in the lowest iron density group consumed the highest amount of calories, protein, fat and the second highest amount of meat, fish, and poultry of all the sex by density groups (Table 13). It can also be concluded from this study that energy and fat intakes appear to decrease as iron density increases, while crude fiber intake increases as iron density increases.

Farley et al. (1985) and Mahoney et al. (1985) in determining the characteristics of diets which provide a high-iron dense intake (i.e. 9 mg per 1000 kcal) have examined food frequency data collected fron 762 subjects aged 24 to 80 years. They too report energy and fat intakes that decrease as iron density increases as well as crude fiber intakes that increase as iron density increases. Vitamin C intake, although relatively constant across density categories in this study, appeared to increase as iron density increased in the Farley et al. (1985) and Mahoney et al. (1985) studies. The high-iron dense diet reported by survey participants in the Mahoney et al. (1985) study consisted of larger portions of vegetables, fruits, and cereal products while those in the low-iron dense group consumed more pastries, beverages, sweets, and added fats. It could be assumed that the high-iron dense diet of children in this study is similar to that reported by Mahoney et al. (1985). It should be noted that in this study only 10% of the males and 9% of the females consumed a high-iron dense diet, while in the Mahoney et al. (1985) study 27% of the women and 16% of the men consumed diets containing 9 mg of iron per 1000 kcal. If the effect of fortified cereals were removed, in the Mahoney et al. (1985) 14% of the women and 6% of the men consumed high-iron diets.

In addition, the highest total available iron and highest nonheme iron consumption in this study were also found in the high-iron dense group. The lowest amount of heme iron and the lowest amount of meat, fish, poultry products consumed, were found in the high-iron dense group. The percent of total iron consumed as nonheme iron for densities 1, 2, and 3 is 90%, 92% and 96% for boys, respectively. The percent of total iron consumed as nonheme iron for densities 1, 2, and 3 is 91%, 90% and 95% for girls, respectively. This leads one to believe the high-iron dense group receives more of its total available iron from nonheme sources, such as vegetables, cereals, and fruits, than from heme iron sources, such as meat products. This would support the assumption that a "high-iron dense diet" has definite, identifiable characteristics, as developed by Mahoney et al. (1985). Further, with future research, it may be possible to predict a "high available iron diet" by those characteristics.

CONCLUSIONS

In this work there were two main objectives. First, to determine: a) the general pattern of consumption of total iron; heme iron; nonheme iron; and the iron from meat, fish, poultry; and the enhancement factors of nonheme iron absorption iron namely, ascorbic acid, and meat, fish or poultry, for each meal/snack; and b) to determine the characteristics involved in an adequate available iron intake. Secondly, this project sought to propose a simple model for the estimation of available iron from daily nutrient intakes which would not be statistically different from the Monsen model (Monsen et al., 1978; Monsen and Balintfy, 1982), a previously published method for the estimation of available iron from meal intake data.

Information developed in Part I, "Meal Pattern of Available Iron; Ascorbic Acid; and Meat, Fish, Poultry Intakes by School Children" gave general recommendations to help maximize iron availability by delineating percent consumption patterns of those factors involved in total available iron intake. It was concluded that the amount of available iron in the diet may be increased by increasing the consumption of enhancement factors at those meals richer in nonheme iron, as shown by the percent consumption patterns. Practical recommendations for the average individual to increase their available iron intake included: 1) serving an ascorbic acid-rich food and/or consumption of meat, fish, poultry on a consistent basis at breakfast; and 2) consumption of meat, fish, poultry and/or a food or beverage high in vitamin C with snacks.

In Part II, "A Model to Estimate Available Iron Intake from Total Iron Consumed", it was concluded that the one large meal (OLM) model and the general consumption pattern (GCP) model predicted similar amounts of total available iron to the Monsen method (Monsen et al., 1978; Monsen and Balintfy, 1982). The simplicity and usefulness of the OLM model, in estimating available iron from total iron consumed, could aid in providing information regarding the overall iron status of a general population, especially where dietary intakes are not recorded on a meal basis, such as with a food frequency methodology. It was also noted here that the OLM model with enhancement factors divided by 1 or 3, and/or possibly by 2, could be used in estimating higher intakes of available iron which, given the present incidence of iron deficiency and knowledge of iron requirements, may be more in line with actual available iron intake.

In Part III, "Available Iron Intakes of School Children Consuming High Iron Density Diets", characteristics of a high-iron dense diet were investigated as they relate to total available iron intake. It was found that the highest total available iron and highest nonheme iron consumption were consumed by those whose total iron intake was 9 mg of iron per 1000 kcal or greater. The lowest amount of heme iron and the lowest amount of meat, fish, poultry products were also consumed by the high-iron dense group. The percent of total iron consumed as nonheme iron was greatest for the high-iron dense group. It was concluded that the high-iron dense group received more available iron from nonheme sources, such as cereals, vegetables and fruits, than from heme iron sources, such as meat products. This supports previously published works defining the characteristics of a "high-iron dense diet" (Farley et. al, 1985; Mahoney et. al, 1985). Further, it was concluded that it may eventually be possible to predict a "high available iron diet" by those characteristics.

Obviously, further research must be done. Other data sets must be used so that actual available iron intakes computed by the Monsen method (Monsen et al., 1978; Monsen and Balintfy, 1982) can be compared to those estimated by the various models. Also, the consumption patterns of those factors involved with available iron intake must be investigated, and the characteristics of high-iron dense diets must be further delineated, using different dietary data sets. The fact that the conclusions reached in this study were derived from only one data set may make it difficult to extrapolate to other data sets.

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APPENDICES

Appendix A: Derivation of Actual Heme Values, Meat Iron, and Grams of Meat, Fish, Poultry per 100g Product.

Table 16. Actual heme values, meat iron, meat type codes, and grams of meat per 100 g of product for all meat, fish, and poultry consumed by study participants.

Food[a] I.D. No.	Mg Actual[b] Heme Iron Per 100 g Product	Mg Total[c] Meat Fe Per 100 g Product	Meat[d] Type Code	Grams[e] Meat/ 100 g Prod- uct
114	0.291	1.700	1	100
126	0.231	3.300	2	100
129	0.287	4.100	2	100
152	0.033	2.900	2	100
224	1.480	3.400	1	100
234	1.660	3.800	1	100
236	1.660	3.300	1	100
244	1.620	2.600	1	100
258	1.620	2.600	1	100
267	1.620	2.600	1	100
268	1.620	2.700	1	100
278	1.480	2.700	1	100
288	1.480	2.900	1	100
290	1.480	3.900	1	100
298	1.480	2.900	1	100
328	1.480	2.600	1	100
333	1.480	2.400	1	100
353	1.620	3.500	1	100
355	1.620	3.700	1	100
358	1.800	3.100	1	100
360	1.800	3.700	1	100
368	1.620	3.500	1	100
369	1.620	2.700	1	100
370	1.620	3.200	1	100
371	0.389	0.840	1	24
377	1.620	4.300	1	100
379	0.794	2.060	1	49
380	2.316	5.100	1	100
381	0.204	0.441	1	13
382	0.373	0.805	1	23
383	0.373	0.805	1	23
682	0.021	1.100	1	100
684	0.338	1.700	1	100
687	1.520	2.300	1	100
701	0.021	1.300	1	100

703	0.340	1.800	1	100
705	0.112	2.700	1	33
707	0.014	1.200	1	65
709	0.187	2.300	1	55
715	0.201	2.300	1	59
717	0.105	2.000	1	31
728	0.021	1.300	1	100
730	0.340	1.800	1	100
734	1.520	1.800	1	100
738	0.181	1.500	1	100
741	0.021	1.300	1	100
748	0.051	0.392	1	28
750	0.042	0.322	1	23
752	0.049	0.378	1	27
756	0.486	1.050	1	30
764	0.958	0.488	1	32
765	0.058	0.488	1	32
771	0.033	7.500	2	100
774	0.015	4.100	2	100
1017	0.033	0.400	2	100
1018	0.033	0.800	2	100
1019	0.033	2.200	2	100
1046	0.214	1.300	1	100
1100	0.033	1.200	2	100
1104	0.033	0.800	2	100
1123	1.223	3.057	1	100
1169	0.033	0.500	2	100
1185	0.840	1.700	1	100
1194	0.940	1.000	1	100
1200	0.940	1.300	1	100
1215	0.970	1.100	1	100
1230	0.940	1.200	1	100
1267	1.620	8.800	1	100
1271	1.520	8.500	1	100
1319	0.033	1.300	2	100
1397	0.033	1.300	2	100
1398	0.033	1.300	2	100
1449	0.011	2.900	2	24
1698	0.287	2.400	2	100
1699	0.287	3.000	2	100
1715	0.490	2.600	2	100
1716	0.490	3.200	2	100
1717	0.490	3.400	2	100
1723	0.490	3.400	2	100
1735	0.420	2.900	2	100
1750	0.680	3.000	2	100
1762	0.340	2.600	2	100
1769	0.420	2.600	2	100
1774	0.420	3.000	2	100
1783	0.420	2.700	2	100
1784	0.440	2.160	2	100
1955	0.033	0.800	2	100
1957	0.033	1.200	2	100
1958	0.033	1.200	2	100

1981	0.287	1.800	2	100
1982	0.287	1.800	2	100
1983	0.287	1.800	2	100
1987	0.287	2.300	2	100
1991	0.287	2.800	2	100
1992	0.287	2.300	2	100
1994	0.287	1.900	2	100
2005	0.287	2.800	2	100
2006	0.287	2.200	2	100
2008	0.287	1.800	1	100
2009	0.287	2.100	2	100
2013	0.287	1.400	2	100
2014	0.287	2.400	2	100
2017	0.287	3.600	2	100
2018	0.287	2.600	2	100
2022	0.287	2.100	2	100
2043	0.033	2.000	2	100
2045	0.033	3.100	2	100
2165	0.214	0.548	1	16
2166	0.214	0.548	1	16
2324	0.033	1.900	2	100
2325	0.033	1.600	2	100
2326	0.016	0.950	2	50
2328	0.282	1.800	1	100
2331	0.282	1.800	1	100
2335	0.045	1.200	1	100
2337	0.520	2.300	1	100
2350	0.065	0.414	1	23
2351	0.065	0.414	1	23
2386	1.280	3.300	1	100
2405	1.620	2.970	1	100
2869	0.670	2.680	1	41
2870	0.570	2.075	1	35
2871	0.930	2.914	1	57
2873	0.770	1.960	1	47
2874	0.013	1.030	2	39
2882	0.181	0.302	1	11
2883	0.473	0.790	1	29

[a]Food I.D. number refers to the identification numbers of Handbook 8 (USDA, 1963a). Foods have been coded and identified by this number.

[b]Actual heme values were calculated from information derived using various sources (Greenberg et al., 1957; Hallberg, 1981b; McDonald's System Inc., 1977; Monsen et al., 1978; Saffle, 1973; Schricker et al., 1982; USDA, 1963a; USDA, 1963b; USDA, 1974; Vahabzadeh, 1982). The equations and sources used are presented in Table 18 of Appendix A.

[c]Total meat iron was taken as 100% of the dietary

iron if the item was deemed to be "pure meat". If the item was a mixed dish or contained products other than "pure meat" the amount of iron coming strictly from the meat portion of the item was calculated. These calculations are presented in Table 18 of Appendix A.

[d]Meat type code refers to the calculations of the Bull and Buss (1980) model (See Methods section of Part II). A number "1" under "meat type code" indicates beef, lamb, red meats, and poultry. A number "2" under "meat type code" indicates pork, bacon, ham, liver, fish.

[e]Grams of meat per 100 g product was taken to be 100 g if the item was deemed to be "pure meat". If the item was a mixed dish or contained products other than "pure meat" the grams of meat in 100 g of that product were calculated. These calculations are present in Table 18 of Appendix A.

Table 17. Listing of food names by Handbook 8 (USDA, 1963b) I.D. number for all types of meat, fish, poultry consumed by participants.

I.D. Number	Food[a]
114	Baby foods, veal, strained
126	Bacon, cured, cooked, drained
129	Bacon, canadian, cooked, drained
152	Bass, striped, cooked, oven-fried
224	Beef, chuck, rib, tot ed, ckd, 69% lean, 31% fat
234	Beef, arm, choice, tot ed, ckd, 85% lean
236	Beef, arm, choice, grd, ckd
244	Beef, flank steak, choice, tot ed, ckd, 100% lean
258	Beef, porterhouse steak, tot ed, ckd, 57% lean
267	Beef, T-bone steak, choice, tot ed, raw 62% lean, 38% fat
268	Beef, T-bone steak, choice, tot ed, ckd, 56% lean, 42% fat
278	Beef, club steak, choice, tot ed, ckd, 58% lean, 42% fat
288	Beef, wedge & rnd bone, sirloin steak, choice, tot ed, ckd
290	Beef, wedge & rnd bone, sirloin steak, choice, grd, ckd

	choice, grd, ckd
298	Beef, dbl-bone, sirloin steak, choice, tot ed, ckd, 66% lean
328	Beef, rib, 6th-12th, choice, tot ed, ckd, 64% lean
333	Beef, rib, 11th-12th, choice, tot ed, ckd, 55% lean
353	Beef, round, entire, choice, tot ed, ckd, 81% lean
355	Beef, round, entire, choice, tot ed, ckd
358	Beef, rump, choice, grd, tot ed, ckd 75% lean, 25% fat
360	Beef, rump, choice, grd, lean, ckd
368	Beef, hamburger, lean w/10% fat, ckd
369	Beef, hamburger, reg grd, raw
370	Beef, hamburger, lean w/12% fat, ckd
371	Beef & veg stew, ckd, home md, lean
377	Beef, corned, boneless, canned, med. fat
379	Beef, corned, boneless, canned, hash
380	Beef, dried, chipped, uncooked
381	Beef, dried, chipped, cooked, creamed
382	Beef, potpie, home md, baked
383	Beef, potpie, comm, frozen, unheated
682	Chicken, all classes, light meat, w/out skin, ckd
684	Chicken, all classes, dark meat, w/out skin, ckd
687	Chicken, fryers, flesh, skin & giblets, ckd, fried
701	Chicken, fryers, light meat, w/out skin, ckd, fried
703	Chicken, fryers, dark meat, w/out skin, ckd, fried
705	Chicken, fryers, back, ckd, fried
707	Chicken, fryers, breast, ckd, fried
709	Chicken, fryers, drumstick, ckd, fried
715	Chicken, fryers, thigh, ckd, fried
717	Chicken, fryers, wing, ckd, fried
728	Chicken, roasters, light meat, w/out skin, ckd
730	Chicken, roasters, dark meat, w/out skin, ckd
734	Chicken, hens & cocks, flesh, skin & giblets, ckd, stew
738	Chicken, hens & cocks, flesh only, ckd, stewed
741	Chicken, hens & cocks, light meat w/out skin, ckd, stewed
748	Chicken, a la king, ckd, home md
750	Chicken potpie, home md, baked
752	Chicken & noodles, ckd, home md
756	Chili con carne, canned
764	Chow mein, chicken, w/out noodles,

	ckd, home md
765	Chow mein, chicken, w/out noodles, canned
771	Clams, raw, hard, or round, meat only
774	Clams, canned, solids & liquids
1017	Fish sticks, frozen, ckd
1018	Flatfishes, (flounders, soles, sanddabs), raw
1019	Flounder, ckd, baked
1046	Goose, domesticated, flesh only, ckd
1100	Haddock, ckd, fried
1104	Halibut, ckd, broiled
1123	Heart, turkey, all classes, ckd
1169	Lake trout, raw
1185	Lamb, leg, choice, tot ed, ckd, 83% lean
1194	Lamb, loin, prime, tot ed, raw, 67% lean
1200	Lamb, loin, choice, tot ed, ckd, 66% lean
1215	Lamb, rib, choice, tot ed, ckd, chops, 62% lean
1230	Lamb, shoulder, choice, tot ed, ckd, 74% lean
1267	Liver, beef, ckd, fried
1271	Liver, chicken, all classes, ckd
1319	Menhaden, atlantic, canned, solids & liq
1397	Ocean perch, redfish, ckd
1398	Ocean perch, redfish, frozen, breaded
1449	Oyster stew, comm, frozen
1698	Pork, fresh, ham, med. fat, raw, 74% lean, 26% fat
1699	Pork, fresh, ham, med. fat, ckd, 74% lean, 26% fat
1715	Pork, fresh, loin, med. fat, raw, 80% lean
1716	Pork, fresh, loin, med. fat, ckd, 80% lean
1717	Pork, fresh, loin, med. fat, ckd, 72% lean
1723	Pork, fresh, loin, ckd, 85% lean
1735	Pork, fresh, boston butt, med. fat, ckd, 79% lean
1750	Pork, fresh, picnic, med. fat, ckd, 74% lean
1762	Pork, fresh, spareribs, med. fat, ckd
1769	Pork, lt-cure, comm, ham, med. fat, ckd, 84% lean
1774	Pork, lt-cure, comm, boston butt, med. fat, ckd
1783	Pork, cured, canned, ham, canned
1784	Pork & gravy, canned, 90% pork
1955	Salmon, pink, humpback, canned
1957	Salmon, sockeye, red, canned
1958	Salmon, ckd, broiled, baked
1981	Bockwurst

1983	Bologna, all meat
1987	Brown-&-Serve sausage, before browning
1991	Cervelat, soft
1992	Country-style sausage
1994	Frankfurters, raw, all samples
2005	Luncheon meat, boiled ham
2006	Luncheon meat, pork, cured ham, chopped
2008	Meat, potted beef, chicken, turkey
2009	Minced ham
2013	Pork sausage, links or bulk, raw
2014	Pork sausage, links or bulk, ckd
2017	Salami, dry
2018	Salami, ckd
2022	Vienna sausage, canned
2043	Shrimp, ckd, french - fried
2045	Shrimp, canned, dry or drained solids
2165	Spaghetti, w/meatballs, tomato sauce, ckd, home made
2166	Spaghetti, w/meatballs, canned
2324	Tuna, canned, in oil, drained
2325	Tuna, canned, water, solids & liq
2326	Tuna salad
2328	Turkey, all classes, tot ed, ckd
2331	Turkey, all classes, flesh only, ckd
2335	Turkey, all classes, light meat, ckd
2337	Turkey, all classes, dark meat, ckd
2350	Turkey potpie, home md, baked
2351	Turkey potpie, comm, frozen, unheated
2386	Veal, plate, med. fat, tot ed, ckd, stewed, 73% lean
2405	Venison, lean meat only, raw
2869	Hamburger - McDonald's
2870	Cheeseburger - McDonald's
2871	Quarter pounder - McDonald's
2873	Big Mac - McDonald's
2874	Filet-O-Fish - McDonald's
2882	Taco w/meat, cheese etc.
2883	Pizza: Moderate amts burger, pepperoni

[a]Food descriptions and abbreviations are the same as those found in Handbook 8 (USDA, 1963b).

Table 18. Sources and equations used to derive actual heme values; meat iron; and grams of meat, fish, poultry per 100 grams product.

Food I.D. Number	Derivation & Source[a]
114	Source: Schricker et al., 1982. 1) $\frac{\text{15.5 g protein}}{\text{100 g baby veal}} * \frac{\text{100 g fresh veal}}{\text{26.1 g protein}}$ $* \frac{\text{0.487 mg heme Fe}}{\text{100 g fresh veal}} = \frac{\text{0.00029 mg heme}}{\text{1 g baby veal}}$ 2) $\frac{\text{0.00029 mg heme}}{\text{1 g baby veal}} * 100 = \frac{\text{0.291 mg heme}}{\text{100 g veal}}$
126	Source: USDA, 1963b; Vahabzadeh, 1981. 1) 3.3 mg iron in bacon; 4.1 mg iron in canadian bacon 2) $\frac{\text{3.3 mg}}{\text{4.1 mg}} = \frac{x}{100} = 80.5\%$ $0.81 * 0.29 \text{ mg heme} = \frac{\text{0.23 mg heme}}{\text{100 g bacon}}$
152, 771, 1017, 1018, 1018, 1100, 1104, 1169, 1319 1397, 1398 1955 ,1957 1958, 2043, 2045, 2324, 2325, 2874	Source: Hallberg, 1981b; USDA, 1963b. 1) Handbook: 300g fish + 100g potatoes = 331 kcal 2) Hallberg: Boiled fish + potatoes = 330 kcal, 0.1 mg heme Fe 3) Therefore: $\frac{\text{.1mg heme}}{\text{300 g fish}} = \frac{\text{0.0333 mg heme}}{\text{100 g fish}}$
224, 234, 236, 244, 258, 267, 268, 278, 288, 290, 298, 328,	Source: Schricker et al., 1982. 1) BF (Leg) = 1.53 mg heme/100g meat 2) GM (Rump) = 1.80 mg heme/100g meat 3) LD (Rib) = 1.48 mg heme/100g meat 4) TB (Arm) = 1.66 mg heme/100g meat

333, 353, 355, 358, 360, 368, 369, 370, 377, 1267, 2405

5) Mean = 1.62 mg heme/100g meat

Source: Schricker et al., 1982;
USDA, 1963a; USDA, 1963b.

371

1) $\frac{\text{24g meat}}{\text{100 g product}} * \frac{\text{0.0162 mg heme}}{\text{1g meat}}$

$= \frac{\text{0.3888 mg heme}}{\text{100 g product}}$

2) $\frac{\text{24 g meat}}{\text{100 g product}} * \frac{\text{3.5 mg Fe}}{\text{100 g meat}}$

$* \text{ 100 g prod} = \frac{\text{0.84 mg Fe}}{\text{100 g prod}}$

Source: Schricker et al., 1982;
USDA, 1974.

379

1) $\frac{\text{49 g corned beef}}{\text{100 g product}} * \frac{\text{1.62 mg heme}}{\text{100 g corned b.}}$

$* 100 = 0.794$ mg heme/100 g product

2) $\frac{\text{49 g corned b.}}{\text{100 g product}} * \frac{x}{\text{4.3 mg Fe}} * 100;$

$x = 2.06$ mg meat Fe/100 g product

Source: Schricker et al., 1982;
USDA, 1963b.

380

1) $\frac{\text{0.0162 mg heme}}{\text{1 g wet beef}} * \frac{\text{5.1 g Fe}}{\text{100 g dry beef}}$

$* \frac{\text{100 g wet beef}}{\text{3.5 g Fe}} = \frac{\text{2.361 mg heme}}{\text{100 g dry beef}}$

Source: Schricker et al., 1982;
USDA, 1963b.

381

1) $\frac{\text{12.6 g meat}}{\text{100 g prod}} * \frac{\text{0.0162 mg heme}}{\text{1 g meat}}$

$* \underline{\text{100 g prod}} = \underline{\text{0.204 mg heme}}$

¶ 1 g meat 100 g prod
¶
¶2) $\frac{12.6\text{ g meat}}{100\text{ g prod}} * \frac{3.5\text{ g Fe}}{100\text{ g meat}}$
¶
¶ $* \frac{100\text{ g prod}}{1\text{ g meat}} = \frac{0.441\text{ mg Fe}}{100\text{ g prod}}$
¶

¶
¶ Source: Schricker et al., 1982;
¶ USDA, 1963a; USDA, 1963b.
¶
382, 383 ¶1) $\frac{23\text{ g beef}}{\text{per 100 g product}} * \frac{0.0162\text{ mg heme}}{1\text{ g meat}}$
¶
¶ $* \frac{1\text{ g meat}}{100\text{ g prod}} = \frac{0.373\text{ mg heme}}{100\text{ g prod}}$
¶
¶2) $\frac{23\text{ g meat}}{100\text{ g prod}} * \frac{3.5\text{ mg Fe}}{100\text{ g meat}}$
¶
¶ $* \frac{100\text{ g prod}}{1\text{ g meat}} = \frac{0.805\text{ mg meat Fe}}{100\text{ g product}}$
¶

¶
¶ Source: Greenberg et al., 1957;
¶ Saffle, 1973.
¶
682 ¶1) $\frac{0.063\text{ mg pigment}}{1\text{ g chicken}} * \frac{3.35\text{ mg Fe}}{1000\text{ mg pigment}}$
¶
¶ $= \frac{0.00021\text{ mg heme}}{1\text{ g chicken}} * 100 =$
¶
¶ $\frac{0.02122\text{ mg heme}}{100\text{ g chicken}}$
¶

¶
¶ Source: Greenberg et al., 1957;
¶ Saffle, 1973.
¶
684 ¶1) $\frac{1.01\text{ mg pigment}}{1\text{ g chicken}} * \frac{3.35\text{ mg Fe}}{1000\text{ mg pigment}}$
¶
¶ $* 100 = \frac{0.338\text{ mg heme}}{100\text{ g chicken}}$
¶

¶
¶ Source: Greenberg et al., 1957;
¶ Saffle, 1973
¶
687, 734, 1271 ¶1) Gizzard = 4.32 mg pigment, Heart =
¶ 3.65 mg pigment, avg. flesh = 0.54,
¶ total = 4.525 mg pigment

¶
¶2) $\frac{4.525 \text{ mg pig}}{1 \text{ g prod}} * \frac{3.35 \text{ mg heme}}{1000 \text{ mg pig}} * 100$
¶
¶ $= \frac{1.52 \text{ mg heme}}{100 \text{ g prod}}$
¶

¶
¶ Source: Greenberg et al., 1957;
¶ Saffle, 1973.
¶
701, 728, 741
¶1) $\frac{0.063 \text{ mg pig}}{1 \text{ g chicken}} * \frac{3.35 \text{ mg heme}}{1000 \text{ mg pig}}$
¶
¶ $* 100 \text{ g chicken} = \frac{0.021 \text{ mg heme}}{100 \text{ g chicken}}$
¶

¶
¶ Source: Greenberg et al., 1957;
¶ Saffle, 1973.
¶
703, 730
¶1) $\frac{1.01 \text{ mg pig}}{1 \text{ g chicken}} * \frac{3.35 \text{ mg heme}}{1000 \text{ mg pig}}$
¶
¶ $= \frac{0.0034 \text{ mg heme}}{1 \text{ g chicken}} * 100 =$
¶
¶ $\frac{0.34 \text{ mg heme}}{100 \text{ g chicken}}$
¶

¶
¶ Source: Schricker et al., 1982; Greenberg
¶ et al., 1957; USDA, 1974.
¶
705
¶1) $\frac{1.01 \text{ mg pigment}}{1 \text{ g meat}} * \frac{3.35 \text{ mg heme}}{1000 \text{ mg pig}}$
¶
¶ $= \frac{0.34 \text{ mg heme}}{100 \text{ g chicken}}$
¶
¶2) $\frac{33 \text{ g meat}}{100 \text{ g prod.}} = \frac{0.34 \text{ mg heme}}{100 \text{ g meat}}$
¶
¶ $= \frac{0.112 \text{ mg heme}}{100 \text{ g product}}$
¶

¶
¶ Source: Greenberg et al., 1957;
¶ Saffle, 1973; USDA, 1974.
¶
707
¶1) Breast is 65% meat
¶2) $.65 * 0.00021 \text{ mg heme} = \frac{0.014 \text{ mg heme}}{100 \text{ g product}}$
¶

¶
¶ Source: Greenberg et al., 1957;
¶ Saffle, 1973; USDA, 1974.
¶
709 ¶1) Drumstick is 55% meat
¶2) 0.55 * 0.0034 = 0.187 mg heme
¶ mg heme 100 g product
¶

¶
¶ Source: Greenberg et al., 1957;
¶ Saffle, 1973; USDA, 1974.
¶
715 ¶1) Thigh is 59% meat
¶2) 0.59 * 0.0034 = 0.201 mg heme
¶ mg heme 100 g product
¶

¶
¶ Source: Greenberg et al., 1957;
¶ Saffle, 1973; USDA, 1974.
¶
717 ¶1) Wing is 31% meat
¶2) 0.31 * 0.0034 = 0.105 mg heme
¶ mg heme 100 g product
¶

¶
¶ Source: Schricker et al., 1982; Greenberg,
¶ et al., 1957.
¶
738 ¶1) 0.54 mg pigment * 3.35 mg Fe
¶ 1 g meat 1000 mg pigment
¶
¶ * 100 = 0.181 mg Fe
¶ 100 g meat
¶

¶
¶ Source: Greenberg et al., 1957;
¶ Saffle, 1973; USDA, 1963b;
¶ USDA, 1974.
¶
748 ¶1) 28% of the recipe is chicken
¶2) 28g meat * 0.0081 mg heme =
¶ 100 g prod 1 g meat
¶
¶ 0.000507 mg heme * 100 =
¶ 1 g product
¶
¶ 0.051 mg heme
¶ 100 g product
¶
¶3) 28 g meat * 1.4 mg Fe * 100g prod
¶ 100 g prod 100 g meat
¶
¶ = 0.392 total meat iron/100 g prod.
¶

¶
¶ Source: Greenberg et al., 1957; Saffle, 1973; USDA, 1963b; USDA, 1974.
¶
750 ¶1) $\frac{23 \text{ g meat}}{100 \text{ g product}} * \frac{0.00181 \text{ mg heme}}{1 \text{ g meat}}$
¶
¶ $* 100 = \frac{0.042 \text{ mg heme}}{100 \text{ g product}}$
¶
¶2) $\frac{23 \text{ g meat}}{100 \text{ g product}} * \frac{1.4 \text{ mg Fe}}{100 \text{ g meat}} * 100$
¶
¶ = 0.322 total meat Fe/100g product
¶

¶
¶ Source: USDA, 1963a; Saffle, 1973.
¶
752 ¶1) $\frac{27 \text{ g meat}}{100 \text{ g product}} * \frac{0.00181 \text{ mg heme}}{1 \text{ g meat}}$
¶
¶ $* 100 = \frac{0.049 \text{ mg heme}}{100 \text{ g product}}$
¶
¶2) $\frac{27 \text{ g meat}}{100 \text{ g product}} * \frac{1.4 \text{ mg Fe}}{100 \text{ g meat}}$
¶
¶ $* 100 = \frac{0.378 \text{ total meat Fe}}{100 \text{ g product}}$
¶

¶
¶ Source: Schricker et al., 1982; USDA, 1963a.
¶
756 ¶1) Product had 7.5 g protein; 7 g protein = 30 g meat.
¶
¶2) $\frac{30 \text{ g meat}}{100 \text{ g prod}} * \frac{3.5 \text{ mg Fe}}{100 \text{ g meat}} * 100$
¶
¶ $= \frac{1.05 \text{ mg total meat iron}}{100\text{g product}}$
¶
¶3) $\frac{30 \text{ g meat}}{100 \text{ g prod}} * \frac{0.0162 \text{ mg heme}}{1 \text{ g meat}}$
¶
¶ $* 100 = \frac{0.486 \text{ mg heme}}{100 \text{ g product}}$
¶

¶
¶ Source: Greenberg et al., 1957;; Saffle, 1973; USDA, 1963b; USDA, 1974.

764, 765

1) $$\frac{32 \text{ g meat}}{100 \text{ g product}} * \frac{0.0081 \text{ mg heme}}{1 \text{ g meat}}$$

$$* 100 = \frac{0.058 \text{ mg heme}}{100 \text{ g product}}$$

2) $$\frac{32 \text{ g meat}}{100 \text{ g meat}} * \frac{1.4 \text{ mg Fe}}{100 \text{ g meat}} * 100$$

$$= \frac{0.488 \text{ mg total meat Fe}}{100\text{g product}}$$

Source: Hallberg, 1981b; USDA, 1974.

774

1) $$\frac{45 \text{ g fish}}{100 \text{ g product}} * \frac{0.033 \text{ mg heme}}{100 \text{ g fish}}$$

$$* 100 = \frac{0.015 \text{ mg heme}}{100 \text{ g product}}$$

Source: Greenberg et al., 1957;
Saffle, 1973.

1046

1) $$\frac{0.64 \text{ mg pigment}}{1 \text{ g meat}} * \frac{3.35 \text{ mg Fe}}{1000 \text{ mg pigment}}$$

$$* 100 = \frac{0.214 \text{ mg heme Fe}}{100 \text{ meat}}$$

Source: Greenberg et al., 1957;
Monsen et al., 1978; Saffle, 1973.

1123

1) $$\frac{3.65 \text{ mg pigment}}{1 \text{ g meat}} * \frac{3.35 \text{ mg Fe}}{1000 \text{ mg pigment}}$$

$$* 100 = \frac{1.223 \text{ mg Fe}}{100 \text{ g meat}}$$

2) If heme iron is approximately 40% of the meat iron then:

$$\frac{1.223 \text{ mg heme Fe}}{x} = \frac{40}{100}$$

$$x = 3.057 \text{ mg meat Fe/100g product}$$

Source: Schricker et al., 1982.

1185, 1194,

1) Leg = 0.84 mg heme/100 g lamb

1200, 1215,	¶2) Rump = 0.97 mg heme/100 g lamb
1230	¶3) Rib = 0.97 mg heme/100 g lamb
	¶4) Arm = 0.97 mg heme/100 g lamb
	¶5) Mean = 0.94 mg heme/100 g lamb
	¶
	¶ Source: Hallberg, 1981b;
	¶ USDA, 1974.
	¶
1449	¶1) 32 g oyster/100 g product
	¶
	¶2) 32 g oyster * 0.00033 mg heme/ 1 g
	¶ fish = 0.011 mg heme/100 g product
	¶
	¶3) $\frac{8.10 \text{ mg Fe}}{89 \text{ g oysters}} = \frac{x \text{ mg Fe}}{32 \text{ g oyster}}$; x =
	¶
	¶
	¶ 2.9 mg Fe/100 g product
	¶
	¶
	¶ Source: Vahabzadeh, 1981.
	¶
1698, 1699,	¶ Sausage cured with NO = 0.287
1981, 1982,	¶ mg/100 g
1983, 1987,	¶
1991, 1992,	¶
1994, 2005,	¶
2006, 2008,	¶
2009, 2013,	¶
2014, 2017,	¶
2018, 2022	¶
	¶
	¶
	¶ Source: Schricker et al., 1982.
	¶
1715, 1761	¶1) Leg = 0.51 mg heme/100 g pork
1717, 1723,	¶2) Rump = 0.42 mg heme/100 g pork
1735, 1750,	¶3) Rib = 0.34 mg heme/100 g pork
1762, 1769,	¶4) Arm = 0.68 mg heme/100 g pork
1774, 1783	¶5) Mean = 0.49 mg heme/100 g pork
	¶
	¶
	¶ Source: Schricker et al., 1982;
	¶ USDA, 1974.
	¶
1784	¶1) $\frac{90 \text{ g pork}}{100 \text{ g prod}} = \frac{x}{0.49 \text{ mg heme}}$;
	¶
	¶ x = 0.44 mg heme/100 g product
	¶
	¶
	¶ Source: Schricker et al., 1982;
	¶ USDA 1963a; USDA, 1963b.
	¶

2165, 2166

¶1) 12% beef + 4% pork = 16% meat

¶2) $\frac{\text{12g beef}}{\text{100 g prod}} * \frac{\text{1.62 mg heme}}{\text{100 g beef}} *$

100 = 0.194 mg beef heme/100g product

¶3) $\frac{\text{4 g pork}}{\text{100 g prod}} * \frac{\text{0.49 mg heme}}{\text{100 g pork}}$

$* 100 = \frac{\text{0.0196 mg pork heme}}{\text{100 g product}}$

¶4) 0.194 + 0.0196 = 0.214 mg total heme/100 g product

¶5) $\frac{\text{12 g beef}}{\text{100 g prod}} * \frac{\text{3.5 mg Fe}}{\text{100 g beef}} * 100$

= 0.42 mg beef iron/100 g product

¶6) $\frac{\text{4 g pork}}{\text{100 g prod}} * \frac{\text{3.2 mg Fe}}{\text{100 g pork}} * 100$

= 0.128 mg pork iron/100 g product

¶7) 0.42 + 0.128 = 0.548 mg meat Fe per 100 g product

¶ Source: Hallberg, 1981b; USDA, 1963b.

2326

¶1) If 100 g tuna salad contains 14.6 g protein and 25 g egg 50 g tuna = 14.2 g protein, then 100g of tuna salad should contain approximately 50 g tuna.

¶2) $\frac{\text{50 g tuna}}{\text{100 g product}} * \frac{\text{1.9 mg total Fe}}{\text{100 g tuna}}$

$*$ 100 = 0.95 mg meat Fe/100 product

¶3) $\frac{\text{0.033 mg heme}}{\text{100 g fish}} = \frac{x}{\text{50 g fish}}$;

x = 0.016 mg heme/100 g product

¶ Source: Saffle, 1973.

2328, 2331, 2335, 2337

¶1) Average for light and dark meat.

¶ 0.8425 mg pigment * 3.35 mg Fe

1 g meat   1000 mg pigment

$$* 100 = \frac{0.2822 \text{ mg heme}}{100 \text{ g meat}}$$

2) Average for light meat.

$$\frac{0.135 \text{ mg pig}}{1 \text{ g meat}} * \frac{3.35 \text{ mg Fe}}{1000 \text{ mg pig}} * 100$$

$$= \frac{0.045 \text{ mg heme}}{100 \text{ g light meat}}$$

3) Average for dark meat.

$$\frac{1.55 \text{ mg pig}}{1 \text{ g meat}} * \frac{3.35 \text{ mg Fe}}{1000 \text{ mg pig}} * 100$$

$$= \frac{0.52 \text{ mg heme}}{100 \text{ g dark meat}}$$

Source: Saffle, 1973; USDA 1963a; USDA 1963b.

2350, 2351 1) $\frac{23 \text{ g turkey}}{100 \text{ g product}} * \frac{0.2822 \text{ mg heme}}{100 \text{ g turkey}}$

$$* 100 = \frac{0.065 \text{ mg heme}}{100 \text{ g product}}$$

2) $\frac{23 \text{ g turkey}}{100 \text{ g product}} * \frac{1.8 \text{ mg Fe}}{100 \text{ g turkey}}$

$$* 100 = \frac{0.414 \text{ mg meat iron}}{100 \text{ g product}}$$

Source: Schricker et al., 1982; USDA, 1974.

2386 1) $\frac{79 \text{ g meat}}{100 \text{ g prod}} = \frac{x}{1.62 \text{ mg heme}}$;

$$x = \frac{1.28 \text{ mg heme}}{100 \text{ g veal}}$$

Source: Schricker et al., 1982; USDA, 1963b.

2405 1) $\frac{1.96 \text{ mg Fe}}{66 \text{ g deer}} * \frac{x}{100 \text{ g deer}}$

x = 2.97 mg meat iron/100g product

¶
¶2) Will use the heme value for lean
¶ beef (i.e 1.62 mg heme/ 100 g meat)
¶

¶
¶ Source: McDonald's System Inc., 1977;
¶ Schricker et al., 1982;
¶ USDA 1963b.
¶
2869 ¶1) A hamburger bun has 0.3 mg Fe;
¶ 2.98 mg Fe - 0.3 mg Fe = 2.68 mg
¶ meat iron per 1 serving.
¶
¶2) 12.9 g total protein - 3.3 g roll
¶ protein = 9.6 g meat protein
¶
¶3) $\frac{7g\ protein}{30\ g\ meat} = \frac{9.6\ g\ pro}{x\ g\ meat}$; x = 41 g meat
¶
¶4) $\frac{41\ g\ meat}{99.3\ g\ wt.} = \frac{x}{100\ g\ prod}$; x =
¶
¶ 41.3 g meat/100 g product
¶
¶5) $\frac{1.62\ mg\ heme}{100\ g\ beef} = \frac{x}{41.3\ g\ beef}$;
¶
¶ x = 0.67 mg heme/serving
¶
¶6) $\frac{0.67\ mg\ heme}{99.3\ g\ wt.} = \frac{0.67\ mg\ heme}{100\ g\ product}$
¶

¶
¶ Source: McDonald's System Inc., 1977
¶ Schricker et al., 1982;
¶ USDA 1963b.
¶
2870 ¶1) 2.87 mg Fe/serving - [0.3 mg for bun
¶ + 0.2 mg Fe for cheese] = 2.37 mg
¶ meat Fe/serving
¶
¶2) 15.6 g total pro - [3.3 g roll pro
¶ + 3.0 g 1/2 oz cheese protein]
¶ = 9.3 g meat protein/serving
¶
¶3) $\frac{40\ g\ meat}{114.2\ wt.} = \frac{x}{100\ g\ prod}$;
¶
¶ x = 35.1 g meat/serving
¶
¶3) $\frac{1.62\ mg\ heme}{100\ g\ beef} = \frac{0.57\ mg\ heme}{35.1\ g\ beef}$
¶
¶ = 0.57 mg heme/serving

¶
¶4) $\frac{0.57 \text{ mg heme}}{114.2 \text{ wt.}} = \frac{0.5 \text{ mg heme}}{100 \text{ g product}}$
¶
¶5) $\frac{2.37 \text{ mg meat Fe}}{114.2 \text{ g total wt.}} = \frac{2.075 \text{ mg meat Fe}}{100 \text{ g product}}$
¶

¶
¶ Source: McDonald's System Inc., 1977;
¶ Schricker et al., 1982;
¶ USDA 1963b.
¶
2871 ¶1) 5.05 mg Fe/serving - 0.30 mg Fe/roll
¶ = 4.75 mg meat Fe/serving
¶
¶2) $\frac{4.75 \text{ mg Fe}}{163 \text{ g wt.}} = \frac{x}{100\text{g}} = \frac{2.914 \text{ meat Fe}}{100 \text{ g product}}$
¶
¶3) 25.6 g total pro - 3.3 g pro/roll =
¶ 22.3 g meat protein
¶
¶4) $\frac{22 \text{ g pro}}{x \text{ g meat}} = \frac{7 \text{ g pro}}{30 \text{ g meat}}$; x = 94 g meat per serving
¶
¶5) $\frac{1.62 \text{ mg heme}}{100 \text{ g beef}} = \frac{1.5 \text{ mg heme}}{94.0 \text{ g beef}}$
¶
¶6) $\frac{1.5 \text{ mg heme}}{163 \text{ g wt.}} = \frac{0.93 \text{ mg heme}}{100 \text{ g product}}$
¶

¶
¶ Source: McDonald's System Inc., 1977;
¶ Schricker et al., 1982;
¶ USDA 1963b.
¶
2873 ¶1) 4.31 total Fe - [0.45 Fe for bun +
¶ 0.20 Fe for cheese] = 3.66 mg meat Fe
¶ per serving.
¶
¶2) 25.6 g total pro - 4.95 g pro/roll
¶ = 20.65 g protein
¶
¶3) $\frac{20.65 \text{ g pro}}{x \text{ g meat}} = \frac{7 \text{ g pro}}{30 \text{ g meat}}$;
¶
¶ x = 88.5 g meat/serving
¶
¶4) $\frac{88.5 \text{ g meat}}{186.7 \text{ g wt}} = \frac{x}{100 \text{ g}}$; x = 47.4
¶
¶ g meat/100 g product
¶
¶5) $\frac{1.62 \text{ mg heme}}{100 \text{ g beef}} = \frac{x}{47.4 \text{ g meat}}$;
¶

¶
¶ x = 0.77 mg heme/100 g product
¶
¶6) $\frac{3.66 \text{ mg Fe}}{186.7 \text{ g wt.}} = \frac{x}{100\text{g}}$; x =
¶
¶ 1.96 mg total meat Fe/100 g product
¶

¶
¶ Source: McDonald's System Inc., 1977;
¶ Schricker et al., 1982;
¶ USDA 1963b.
¶
2874 ¶1) $\frac{11.8 \text{ g pro}}{x \text{ g fish}} = \frac{7 \text{ g protein}}{30 \text{ g fish}}$;
¶
¶ x = 51 g fish/serving
¶
¶2) $\frac{51 \text{ g fish}}{131.3 \text{ g wt.}} = \frac{38.3 \text{ g fish}}{100 \text{ g product}}$
¶
¶3) 1.33 mg total Fe - 0.30 mg Fe
¶ per roll = 1.03 mg fish Fe/100g prod.
¶
¶4) $\frac{0.033 \text{ mg heme}}{100 \text{ g fish}} = \frac{x}{38.3 \text{ g fish}}$
¶
¶ x = 0.013 mg heme/100 g product
¶

¶
¶ Source: Schricker et al., 1982;;
¶ USDA 1963a; USDA, 1963b.
¶
2882 ¶1) $\frac{1.63 \text{ mg Fe}}{250 \text{ g taco}} = \frac{x}{100 \text{ g}}$;
¶
¶ x = 0.652 mg Fe/100g product
¶
¶2) $\frac{28 \text{ g beef}}{250 \text{ g prod}} * \frac{1.62 \text{ mg heme}}{100 \text{ g beef}} * 100$
¶
¶ $= \frac{0.181 \text{ mg heme}}{100 \text{ g beef}}$
¶
¶3) $\frac{28 \text{ g beef}}{250 \text{ g prod}} * \frac{2.7 \text{ mg Fe}}{100 \text{ g beef}} * 100$
¶
¶ $= \frac{0.302 \text{ mg meat Fe}}{100 \text{ g product}}$
¶
¶4) $\frac{28 \text{ g meat}}{250 \text{ g prod}} = \frac{11.2 \text{ g meat}}{100 \text{ g product}}$
¶
¶

¶
¶ Source: Schricker et al., 1982;
¶ USDA, 1963a; USDA 1963b.
¶
2883 ¶1) $\frac{1.96 \text{ mg Fe}}{245 \text{ g product}} * \frac{x}{100 \text{ g}}$;
¶
¶ x = 29.18g beef/100g product
¶
¶2) $\frac{255 \text{ g meat}}{874 \text{ g wt.}} = \frac{x}{100 \text{ g prod}}$; x =
¶
¶ 29.18 g beef/100 g product
¶
¶3) $\frac{1.62 \text{ mg heme}}{100 \text{ g beef}} * \frac{x}{29.18} \text{ g beef}$
¶
¶ $* 100 = \frac{0.473 \text{ mg heme}}{100 \text{ g product}}$
¶
¶4) $\frac{2.7 \text{ mg Fe}}{100 \text{ g beef}} = \frac{x}{29.18 \text{ g}} \text{ beef}$; x =
¶
¶ $\frac{0.79 \text{ mg total meat Fe}}{100 \text{ g product}}$
¶

---

[a]Full references for the sources are found in the Reference section.

Appendix B: Outline of Steps Used in Computing the Models

Introduction

Given below in outline form are the actual steps used in writing the computer programs to generate the models. Immediately preceding the step a number is given in parentheses. These indicate the original numbered steps used in writing the computer programs and are given because they are referred to in the computer programs. The original raw data from the Nutrition, Behavior and School Performance study, (Hendricks et al., 1981), upon which the following steps were run, can be found on the computer tape "School".

All data is the average of the number of days eaten. For example, the sum of two days of intake is divided by two and compiled into "one average day". If consumption was recorded for one day, the daily totals have been divided by one and recorded as "one average day".

Outline

I. PRELIMINARY DATA GENERATED

A. Raw data totals calculated.

1) "g MFP per meal". Sum the grams of meat, fish, poultry (MFP) consumed at each meal and at each snack eaten by each individual. This should result in separate totals for each meal and snack. (1)[a]

2) "g MFP per day". Total the grams of meat, fish, poultry consumed daily by each individual. (2)

3) "mg iron per meal". Sum the mg of total dietary iron consumed at each meal and at each snack for each individual. Results will be separate totals for each meal and snack. (3)

4) "mg iron per day". Total the dietary iron (in mg) consumed daily by each individual. (4)

5) "mg Vit. C per meal". Sum the mg of Vitamin C consumed at each meal and at each snack for each individual. Results will be separate totals for each meal and snack. (5)

6) "mg Vit. C per day". Total the Vitamin C (in mg) consumed daily by each individual. (6)

7) "mg actual heme iron per meal". Sum the mg of actual heme iron consumed at each meal and at each snack. Results will be separate totals. (7a)

8) "mg actual heme iron per day". Total the mg of actual heme iron consumed daily by each individual. (7b)

9) "mg MFP iron per meal". Sum the mg of iron contained in the grams of meat, fish, poultry (MFP), summed in step #I,A,1, consumed at each meal and at each snack, eaten by each individual. This should result in separate totals for each meal and snack of mg of MFP iron consumed per meal. (8)

10) "mg MFP iron per day". Total the iron contained in the grams of MFP consumed daily (calculated in step I,A,2) by each individual. (9)

II. COMPUTING THE MODELS

A. Monsen's model (The control)

1) "calculated heme iron per meal". Compute 40% of the total meat iron consumed (calculated in step #I,A,9) at each meal and at each snack by each individual. Record this number for each meal and for each snack (separate totals). This is the amount of heme iron consumed at each meal and at each snack by each individual. (10)

3) "available calculated heme Fe per meal". Compute 23% (i.e. multiplied by 0.23) of the amount of heme iron consumed at each meal and at each snack by each individual (calculated in step #II,A,1). Record for each meal and for each snack for each individual. This is the amount of available heme iron in each meal and in each snack for each individual. (12)

4) "units of EF per meal". Add the mg of Vitamin C consumed by each individual at breakfast (calculated in step #I,A,5) plus the grams of MFP consumed at breakfast (calculated in step #I,A,1). The product of this calculation must be 75 or less. If the product is 75 or greater it should default back to 75. Repeat this operation for lunch, dinner, and each snack. These numbers are the "units" of enhancement factor (EF) available for the particular meal in question. (13)

5) "percent absorption of nonheme Fe per meal". Determine the percent absorption of nonheme iron by

the following: $\% \text{ absorption} = 3 + 8.93 * \log_e \frac{(EF + 100)}{100}$;

Determine for each meal using the units of EF present at each meal as calculated in step #II,A,4. This results in a percent absorption for nonheme iron for each meal and snack (need it in decimal form). If no enhancement factors are present for the meal the percent absorption defaults to 3%, or .03. (14)

6) "nonheme Fe per meal". Determine the amount of nonheme iron consumed at each meal as follows: nonheme iron at breakfast = total iron consumed at breakfast (step #I,A,3) - heme iron consumed at breakfast, (step #II,A,1). Repeat for each meal and snack. (15)

8) "available nonheme Fe per meal". Determine the amount of nonheme iron available to be absorbed at breakfast by multiplying the percent of nonheme iron absorption for the breakfast meal (calculated in step #II,A,5) by the amount of nonheme iron consumed at the breakfast meal (calculated in step #II,A,6). Repeat for each meal and snack. (17)

9) "total available Fe per meal". Add the amount of available heme iron (calculated in step #II,A,3) for the breakfast meal to the available of nonheme iron at breakfast, (calculated in step #II,A,7), to get the total amount of available iron at the breakfast meal. Repeat for each meal and snack. Repeat for each individual. (18)

10) "total available iron per day usiing the Monsen model". Sum the total amount of available iron at breakfast with that at lunch, (calculated in step #II,A,8), with that of dinner and all snacks. Repeat for each individual. (19)

B. One Large Meal

1) Computing the one large meal model using a percentage or calculated heme value.

a) "units of EF. Add the totals of MFP (in grams) consumed for the day by each individual, (calculated in step #I,A,2), to the total of Vitamin C (in mg) consumed for the day, (calculated in step #I,A,6), to arrive at the units of EF for the one large meal model. Divide the total amount of enhancement factor consumed per day by the following denominators: 1,3,4,5,6 (20).

b) "percent absorption on nonheme iron per day". Determine the percent absorption of nonheme iron absorption by the following:

$$\% \text{ absorption} = 3 + 8.93 * \log_e \frac{(EF + 100)}{100};$$

This will be calculated for each individual; for each of the enhancement factors and needs to be in decimal form. If no enhancement factors are present for the meal the percent absorption defaults to 3% ,or 0.03. (21)

c) "calculated heme per day". Calculate total daily heme iron for the OLM model. Heme iron per day = total daily meat iron, (calculated in step #I,A,10), * .40. (22a)

d) "nonheme iron per day". Calculate daily nonheme iron for the OLM model. Nonheme iron per day = total dietary iron per day, (step #I,A,4), - total heme iron per day, (step #II,B,1,c). (22b)

e) "available nonheme iron per day". Calculate the daily available nonheme iron for each individual by the following: daily available nonheme iron = total daily nonheme iron, (step #II,B,1,d), multiplied by the percent absorption of nonheme iron for each of the enhancement factors, (calculated in step #II,B,1,b). Repeat for each individual. This results in five separate available nonheme irons. (22c)

f) "available calculated heme iron per day". Calculate total daily available heme iron for each individual by the following: daily available heme iron = total heme iron per day, (calculated in step #II,B,1,c), multiplied by 0.23. (23)

g) "total available iron per day for the OLM model using calculated heme values". Calculate total daily available iron for each individual by the following: Total daily available iron = daily available nonheme iron, (step #II,B,1,e), for each of the daily available nonheme irons, + daily available heme iron, (calculated in step #II,B,1,f). This results in five separate total available irons per day. Repeat for each individual. (24)

2. Computing the one large meal model using actual heme values

a) "actual available heme iron per day". Calculate daily actual available heme iron: actual available heme iron = 0.23 * actual heme consumed per day, per individual, (calculated in step #I,A,8). Repeat for each individual. (25)

b) "actual nonheme iron per day". Calculate total daily nonheme iron using actual values. Actual nonheme iron per day = total daily iron, (calculated in step #I,A,4), - actual heme iron per day, (calculated in step #I,A,8). (25a)

c) "actual available nonheme iron". Calculate total daily available nonheme iron using actual values. Total actual available nonheme iron per day = actual nonheme iron per day, (calculated step #II,B,2,b), multiplied by percent absorption for nonheme iron, (calculated in step #II,B,1,b). This results in five separate actual available nonheme irons. (25b)

d) "actual total available iron for the OLM model". Calculate total available iron using actual heme values for the OLM model: total available iron using actual heme values for the OLM model = available actual heme iron, (calculated in step #II,B,2,a), + available actual nonheme iron, (calculated in step #II,B,2,c). This results in five separate actual total available irons. Repeat for each individual. (26)

C. The Bull & Buss Model

1) Computing the model of Bull & Buss using a percentage of calculated value for heme iron.

a) "meat categories". Divide meats consumed into two categories: 1) beef, lamb, other red meats, poultry; and 2) pork, bacon, ham, liver, fish. Record the dietary iron contained in each group of meat. Total the dietary iron consumed in each group of meat for each individual. (27)

b) "heme iron per day, category '1'". Calculate 60% of the dietary iron of the meat consumed in group "1" of step #II,C,1,a. Record. Repeat for each individual. (28)

c) "heme iron per day, category '2'". Calculate 40% of the dietary iron of the meat consumed in group "2" of step #II,C,1,a. Record. Repeat for each individual. (29)

d) "total heme per day for Bull & Buss model". Sum the totals of the calculations of steps II,C,1,b and II,C,1,c. This is the amount of total heme iron each individual has consumed per day for the Bull & Buss model. Repeat for each individual. (30)

e) "available heme iron per day for Bull & Buss model". Compute 23% of the total heme iron consumed by each individual per day, (calculated in step #II,C,1,d). This gives the available heme iron per person, per day, for the Bull and Buss model. (31)

f) "fortification iron per day". Calculate 11% of the total dietary iron consumed per person, per day, (calculated in step #I,A,4). This is the total amount of fortification iron consumed by each individual. Repeat this step for each individual. The figure of 11% was taken from Bull & Buss (1980). (32)

g) "available fortification iron". Calculate 5% of the total amount of fortification iron consumed by each individual. This is the available fortification iron. Repeat this step for each individual. (33)

h) "nonheme iron per day for Bull & Buss". Calculate the amount of nonheme iron consumed by each individual for the Bull & Buss model as follows: nonheme food iron consumed per day = total iron consumed per day, (step #I,A,4), minus the sum of [total heme iron in the Bull & Buss model (step #II,C,1,d) + total fortification iron (step #II,C,1,f)]. (34)

i) "available nonheme iron per day for Bull & Buss". Calculate 5% of the total amount of nonheme iron consumed, (step #II,C,1,h), for each individual. This is the available nonheme iron per person, per day. (35)

j) "total available iron for Bull & Buss model". Sum: available heme iron, (step #II,C,1,e), + available fortification iron, (step #II,C,1,g), + available nonheme iron, (step #II,C,1,i) = total available iron for the Bull & Buss model. Repeat for each individual. This is the total available iron for the Bull & Buss model using a percentage figure for for the heme values. (36)

2. Computing the Bull & Buss model using "actual" heme values.

a) "actual available nonheme iron per day for Bull and Buss". Calculate the amount of actual nonheme iron. The amount of actual nonheme iron = total daily iron, (step #I,A,4), - daily fortification iron, (step #II,C,1,f), - daily actual heme iron consumed, (step #I,A,7). (37a)

b) "available actual nonheme iron per day for Bull & Buss". Calculate available actual nonheme iron. Available actual nonheme iron = the amount of actual nonheme iron consumed, (step II,C,2,a), * .05 (5%). (37b)

c) "total available iron per day for Bull & Buss". Calculate total available iron for the Bull & Buss using actual heme iron values as follows: total available iron for the Bull & Buss using actual heme iron values = available actual heme iron, (calculated in step #II,B,2,a), + available actual nonheme iron, (calculated in step #II,C,2,b), + available fortification iron, (calculated in step #II,C,1,g). Repeat for each individual. This is the total available iron for the Bull & Buss model using actual heme iron values. (37c)

D. GENERAL CONSUMPTION PATTERN

1) Calculating the general consumption pattern.

a) "average percent of enhancement factors consumed each meal". Determine the percentages of the following consumed per person for each meal: (38)

1) Determine the percentage of Vitamin C consumed at breakfast by:

$$\frac{\text{mg Vit C consumed at breakfast (I,A,5)}}{\text{total mg Vit C consumed daily (I,A,6)}} * 100$$

Repeat for each meal and snack.
Repeat for each individual. (38a)

2) Determine the percentage of total iron consumed at breakfast by:

$$\frac{\text{mg consumed at breakfast (I,A,3)}}{\text{total mg consumed daily (I,A,4)}} * 100$$

Repeat for each meal and snack.
Repeat for each individual. (38b)

3) Determine the percentage of actual heme iron consumed at breakfast by:

$$\frac{\text{mg consumed at breakfast (I,A,7)}}{\text{total mg consumed daily (I,A,8)}} * 100$$

Repeat for each meal and snack.
Repeat for each individual. (38c)

4) Determine the percentage of meat, fish, poultry consumed at breakfast by:

$$\frac{\text{mg consumed at breakfast (I,A,1)}}{\text{total mg consumed daily (I,A,2)}} * 100$$

Repeat for each meal and snack.

Repeat for each individual. (38d)

5) Determine the percentage of meat iron consumed at breakfast by:

$$\frac{\text{mg consumed at breakfast (I,A,8)}}{\text{total mg consumed daily (I,A,9)}} * 100$$

Repeat for each meal and snack.
Repeat for each individual. (38e)

b) "determining the average GCP". Determine the median, mode, mean, range, standard deviation of the percentages calculated in step #II,D,1,a. From this determine an acceptable GCP such as the following hypothetical example used here to illustrate the calculations needed: (39)

Hypothetical Example of the GCP

	Breakfast	Lunch	Dinner	Snacks
Actual Heme Fe	10%	30%	45%	15%
Vitamin C	25%	20%	40%	15%
Total Iron	20%	25%	40%	15%
Meat, Fish or Poultry	10%	30%	45%	15%
Meat Iron	10%	30%	45%	15%

2) Breaking totals into the hypothetical meals (To calculate available Fe using a % figure for the heme values):

a) "determining the estimated meals". Use the GCP to break totals of Vitamin C; total iron; and grams of meat, fish and poultry consumed back into "meals" as follows: (40)

1) Breakfast:
a) Compute 25% (this is the percent of Vit. C consumed at breakfast in the hypothetical example. These hypothetical numbers will be used to illustrate calculations in this narrative) of the total amount of vitamin C consumed, (calculated in step #I,A,6). Repeat for each individual and record as estimated mg of Vit. C consumed at breakfast. (40a)

2) Repeat for each meal using whatever percent is appropriate from the actual GCP. (40b)

3) Repeat for each individual. (40c)

4) Repeat for total iron and grams MFP consumed. (40d)

5) This should result in a new set of estimated amounts of vitamin C, total iron, actual heme iron, meat iron and MFP consumed by each individual. (40e)

3)Calculating available iron using a percentage of calculated heme iron value.

a) heme iron per estimated meal for calculated heme iron values". Compute 40% of the meat iron consumed in the hypothetical meals, (calculated in step #II,D,1,a,5), for each meal, and for each snack, by each individual. Record this number for each meal, and for each snack (separate totals). This is the amount of heme iron consumed at each meal, and at each snack, by each individual. (41a)

b) "available heme iron per estimated meal for calculated heme iron values". Compute 23%, (i.e. multiplied by 0.23), of the amount of heme iron consumed at each meal and at each snack by each individual, (calculated in step #II,D,3,a). Record for each meal and for each snack for each individual. This is the amount of available heme iron in each meal and in each snack for each individual. (41b)

c) "units EF per estimated meal for calculated heme iron values". Add the mg of Vitamin C consumed by each individual at the hypothetical breakfast, (step #II,D,2,a,5), plus the grams of MFP, (step #II,D,2,a,5), consumed at the hypothetical breakfast. The product of this calculation must be 75 or less. If the product is 75 or greater it should default back to 75. Repeat this operation for lunch, dinner, and each snack. These numbers are the "units" of enhancement factor (EF) available for the particular hypothetical meal in question. (41c)

d) "percent absorption nonheme iron per estimated meal for calculated heme iron values". Determine the percent absorption of nonheme iron by the following:

$$\% \text{ absorption} = 3 + 8.93 * \log_e \frac{(EF + 100)}{100};$$

Determine for each meal using the units of EF present at each meal as calculated in step II,D,3,d. This results in a percent absorption of nonheme iron for each meal and snack (need it in decimal form). If no enhancement factors are present for the meal the percent absorption defaults to 3% ,or .03. (41d)

e) "nonheme iron per estimated meal for calculated heme iron values". Determine the amount of nonheme iron consumed at each meal as follows: nonheme iron at breakfast = total iron consumed at breakfast, (step

#II,D,2,a), - heme iron consumed at breakfast, (step #II,D,3,a). Repeat for each meal and snack. (41e)

f) "available nonheme iron per estimated meal for calculated heme iron values". Determine the amount of nonheme iron available to be absorbed at breakfast by multiplying the percent absorption of nonheme iron for the breakfast meal, (calculated in step #II,D,3,d), by the amount of nonheme iron consumed at the breakfast meal, (calculated in step #II,D,3,e). Repeat for each meal and snack. (41g)

g) "total available iron per estimated meal for calculated heme iron values". Add the amount of available heme iron, (calculated in step #II,D,3,b), for the breakfast meal to the amount of nonheme iron available to be absorbed at breakfast, (calculated in step #II,D,3,f), to get the total amount of available iron at the breakfast meal. Repeat for each meal and snack. Repeat for each individual. (41h)

h) "total available iron per estimated meal using calculated heme values". Sum the total amount of available iron at breakfast with that at lunch, (calculated in step #II,D,3,g), with that of dinner and all snacks. This is total available iron for the estimated meals of the GCP model, using a percentage (i.e. calculated figure for the heme iron values). Repeat for each individual. (41i)

4) Calculating available Fe using actual heme iron values.

a) "actual heme iron per estimated meals using actual heme iron values". Compute the amount of actual heme iron consumed at each hypothetical meal and each snack by each individual using the percents of the GCP to give the mg of actual heme iron consumed at each meal and snack. Record this number for each meal and for each snack (separate totals). This is the amount of actual heme iron consumed at each meal, and at each snack, by each individual, using the hypothetical meals arrived through use of the GCP. (42)

b) "available actual heme iron per estimated meal" using actual heme iron values". Compute 23% (i.e. multiplied by 0.23) of the amount of actual heme iron consumed at each meal, and at each snack, by each individual, (calculated in step #II,D,4,a). Record for each meal, and for each snack, for each individual. This is the amount of available actual heme iron in each meal and in each snack for each individual using the estimated or hypothetical meals arrived at through use of the GCP. (43)

c) "units of EF per estimated meals using actual heme iron values." Add the mg of Vitamin C consumed by each individual at the hypothetical breakfast plus the grams of MFP consumed at the hypothetical breakfast. The product of this calculation must be 75 or less. If the product is 75 or greater it should default back to 75. Repeat this operation for lunch, dinner and each snack. These numbers are the "units" of enhancement factor (EF) available for the particular hypothetical meal in question. (44)

d) percent absorption of nonheme iron per estimated meal using actual heme values". Determine the percent absorption of nonheme iron by the following:

$$\% \text{ absorption} = 3 + 8.93 * \log_e \frac{(EF + 100)}{100};$$

Determine for each meal using the units of EF present, at each hypothtical meal, as calculated in step #II,D,4,c. This results in a percent absorption for nonheme iron, for each meal, and snack (need it in decimal form). (45)

e) "nonheme iron per estimated meal using actual heme values". Determine the amount of nonheme iron consumed at each meal as follows: nonheme iron at breakfast = total iron consumed at breakfast, (step #II,D,2,a,5), - actual heme iron consumed at breakfast, (step #II,D,2,a,5). Repeat for each meal and snack. (46)

f) "available nonheme iron per estimated meal using actual heme iron values". Determine the amount of actual nonheme iron available to be absorbed at breakfast by multiplying the percent of nonheme iron absorption for the breakfast meal, (calculated in step #II,D,4,d), by the amount of actual nonheme iron consumed at the breakfast meal, (calculated in step #II,D,4,e). Repeat for each meal and snack. (48)

g) "total available iron per estimated meal using actual heme iron values". Add the amount of available heme iron, (calculated in step #II,D,4,b), for the breakfast meal to the amount of nonheme iron available to be absorbed at breakfast, (calculated in step #II,D,4,e), to get the total amount of available iron at the breakfast meal. Repeat for each meal and snack. Repeat for each individual. (49)

h) "total available iron per day for GCP using actual heme values". Sum the total amount of available iron at breakfast with that at lunch, (calculated in step

#II,D,4,g), with that of dinner and all snacks. This is the total available iron for the GCP using actual heme values. Repeat for each individual. (50)

III. Final Data Computed.

A. Final files.

1) From the preceding steps compile the following nutrients into final files for meals 1,2,3,4,5,6 and daily totals. These should be listed by subject I.D. number and should be done for each individual.

a) Mg Iron consumed.
b) Mg Vitamin C consumed.
c) Grams of meat, fish, poultry consumed as calculated by the Monsen model.
d) Mg of enhancement factor consumed as calculated by the Monsen model.
e) Mg of heme iron consumed as calculated by the Monsen model.
f) Mg of nonheme iron consumed as calculated by the Monsen model.
g) Mg of total available iron consumed as calculated by the Monsen model.

2) From the preceding steps compile into the final file for meals 1,3,5, daily totals, and for the sum of meals 2+4+6 the following nutrients listed. These should be listed by subject I.D. number and should be done for each individual.

a) Mg Iron consumed.
b) Mg Vitamin C consumed.
c) Grams of meat, fish, poultry consumed as calculated by the Monsen model.
d) Mg of enhancement factor consumed as calculated by the Monsen model.
e) Mg of heme iron consumed as calculated by the Monsen model.
f) Mg of nonheme iron consumed as calculated by the Monsen model.
g) Mg of total available iron consumed as calculated by the Monsen model.

3) Age
4) Sex
5) Height
6) Weight
7) Total carbohydrate consumed for the day
8) Total protein consumed for the day.
9) Total fat consumed for the day.
10) Total kcal consumed for the day.
11) Iron consumption per 1000 kcal consumed (i.e. iron density per 1000 kcal).
12) Mg of nonheme iron consumed as calculated by the method of Bull & Buss.

13) Mg of heme iron consumed as calculated by the method of Bull & Buss.
14) Mg of heme iron consumed as calculated by the one large meal method.
15) Mg of nonheme iron consumed as calculated by the one large meal method.
16) Mg of meat iron of group "a" or "1" consumed per day.
17) Mg of meat iron of group "b" or "2" consumed per day.
18) Mg of total available iron consumed as calculated by the one large meal method using actual heme values.
19) Mg of total available iron consumed as calculated by the one large meal method using a percentage or calculated values for the heme values.
20) Mg of total available iron consumed as calculated by the Bull & Buss method using actual heme values.
21) Mg of total available iron consumed as calculated by the Bull & Buss method using a percentage or calculated values for the heme values.
22) Mg of total available iron consumed as calculated by the general consumption pattern method, using actual heme values.
23) Mg of total available iron consumed as calculated by the general consumption pattern method using a percentage, or calculated value, for the heme values.
24) Compile into the final file for the estimated meals 1,2,3,4 and daily totals of the general consumption pattern, the following nutrients listed. These should be listed by subject I.D. number and should be done for each individual.
   a) Mg Iron consumed.
   b) Mg Vitamin C consumed.
   c) Grams of meat, fish, poultry consumed as calculated by the GCP model.
   d) Mg of enhancement factor consumed as calculated by the GCP model.
   e) Mg of heme iron consumed as calculated by the GCP model.
   f) Mg of nonheme iron consumed as calculated by the GCP model.
   g) Mg of total available iron consumed as calculated by the GCP model, from actual heme values.
   h) Mg of total available iron consumed as calculated by the GCP model from a percentage, or calculated heme value.

[a]Each step was numbered more or less sequentially when first written and incorporated into the computer programming. The numbers in parenthesis immediately following each step refer

to those numbers. The computer programming also refers to that number.

Appendix C: Documentation of Computer Files Used to Calculate the Models

Introduction

This appendix contains the documentation of the computer files used to generate the models used in this project. They are in alphabetical order. The actual files are recorded on the conputer tape "Darks".

Documentation

FILE: DAILYS.DAT, DAILYSRT.DAT

NOTE:

1) DAILYS.DAT is a file of 1 record per person.
2) The data is derived from 6 other files.
3) This file is formatted as follows: (I5, 2F6.2, 2I2, F5.0, 3F5.1, F4.1, F5.2, 2F5.1, F4.2, F5.2, F6.3, 17F4.2, 5F5.1, 10F4.2, 2(2F4.2, F5.2), F4.2, F5.2, 4F4.2, 2F5.3, 2(F5.2, F4.2).

FORMAT:

ITEM	FORMAT	COLUMNS	CONTENT
1	I5	1-5	I.D. #
[From HOLDSAHW.DAT]			
2	F6.2	6-11	Height
3	F6.2	12-17	Weight
4	I2	18-19	Sex
5	I2	20-21	Age
[From MODELSP1.DAT (Val 6(21))]			
6	F5.0	22-26	Total day's kcal
[From DIETAVNTS.DAT (Nut(7,3), Mornut(4))]			
7	F5.1	27-31	Total daily protein consumed (grams)
8	F5.1	32-36	Total daily fat consumed (g)
9	F5.1	37-41	Total daily carbohydrate consumed (g)
10	F4.1	42-45	Total daily crude fiber consumed (g)
11	F5.2	46-50	Total daily iron consumed (mg)
12	F5.1	51-55	Total daily vit. C consumed (mg)
[From MFPHEMAVE.DAT (MFP(7,3))]			
13	F5.1	56-60	grams meat, fish, poultry (MFP)

			consumed per day
14	F4.2	61-64	mg of iron contained in the grams of MFP consumed
15	F5.2	65-69	mg actual heme Fe consumed

[Calculated from current program]

16	F6.3	70-75	mg Fe/1000 kcal

[From MODELSP1.DAT (Val 6(21))]

17	F4.2	76-79	Total available iron (Monsen)
18	F4.2	80-83	Total available Fe for one large meal derived using calc'd heme values and an EFO divided by 1 (i.e. TAFOC(1)).
19	F4.2	84-87	TAFOC(2)(i.e. divided by 3)
20	F4.2	88-91	TAFOC(3)(i.e. divided by 4)
21	F4.2	92-95	TAFOC(4)(i.e. divided by 5)
22	F4.2	96-99	TAFOC(5)(i.e. divided by 6)
23	F4.2	100-103	Total available Fe for one large meal derived using actual or literature derived heme values and an EFO divided by 1 (i.e. TAFOA(1)).
24	F4.2	104-107	TAFOA(2)(i.e. divided by 3)
25	F4.2	108-111	TAFOA(3)(i.e. divided by 4)
26	F4.2	112-115	TAFOA(4)(i.e. divided by 5)
27	F4.2	116-119	TAFOA(5)(i.e. divided by 6)
28	F4.2	120-123	TACIB - Total available iron for the Bull & Buss model using calc'd heme values and a 5% absorption for fortification Fe
29	F4.2	124-127	TAVDIB - Total available iron for Bull & Buss using actual or value derived (i.e. literature derived heme values and a 5% absorption for fortification Fe
30	F4.2	128-131	TACIB1 - Total available iron for Bull & Buss using calc'd heme values and a 1% absorption for fortification Fe
31	F4.2	132-135	TAVDIB1 - Total available iron for Bull & Buss using value derived heme iron values (i.e. actual heme values) and a 1% absorption for fortification Fe

[From MODELSP2.DAT (Val8(2))]

32	F4.2	136-139	Total available Fe (TAFE) using calc'd heme values and the general consumption pattern (GCP)
33	F4.2	140-143	TAFE using actual heme values and the GCP

[From MODELSP1.DAT (Val 6(21))]

34	F5.1	144-148	Enhancement factor for one large meal, EFO(1) divided by 1
35	F5.1	149-153	EFO(2) divided by 3
36	F5.1	154-158	EFO(3) divided by 4
37	F5.1	159-163	EFO(4) divided by 5
38	F5.1	164-168	EFO(5) divided by 6

[From MDLSXTRA2.DAT (Val 7(18))]

39	F4.2	169-172	ANHFOC(1) - Available nonheme Fe, OLM, using calc'd heme values and EFO(1) (i.e. enhancement factors divided by 1)
40	F4.2	173-176	ANHFOC(2) (i.e. divisor = 3)
41	F4.2	177-180	ANHFOC(3) (i.e. divisor = 4)
42	F4.2	181-184	ANHFOC(4) (i.e. divisor = 5)
43	F4.2	185-188	ANHFOC(5) (i.e. divisor = 6)
44	F4.2	189-192	ANHFOA(1) - Available nonheme Fe, OLM, using actual heme values and EFO(1)
45	F4.2	193-196	ANHFOA(2) (i.e. divisor = 3)
46	F4.2	197-200	ANHFOA(3) (i.e. divisor = 4)
47	F4.2	201-204	ANHFOA(4) (i.e. divisor = 5)
48	F4.2	205-208	ANHFOA(5) (i.e. divisor = 6)
49	F4.2	209-212	DCHF - Day's total calc'd heme Fe (Monsen)
50	F4.2	213-216	DACHF - Day's total available calc'd heme Fe (Monsen)
51	F5.2	217-221	DNONH - Day's total nonheme Fe (Monsen)
52	F4.2	222-225	DANHF - Daily available nonheme Fe (Monsen)
53	F4.2	226-229	HFOC - Heme Fe, OLM, using calc'd heme values
54	F5.2	230-234	NONHOC - Nonheme Fe, OLM, using calc'd heme values
55	F4.2	235-238	AHFOC - Available heme Fe, OLM, using calc'd heme values
56	F5.2	239-243	NHFOA - Nonheme Fe, OLM, using actual heme values
57	F4.2	244-247	AHFOA - Available heme Fe, OLM, using actual heme values
58	F4.2	248-251	CHIB - Calc'd heme iron, Bull & Buss
59	F4.2	252-255	ACHIB - Available calc'd heme iron, Bull & Buss
60	F4.2	256-259	FORT - Estimate of the amount of fortification Fe present, (i.e. 11% of total Fe present in the Bull & Buss model)
61	F5.3	260-264	AFORT - Available fortification Fe at a 5% absorption level (B&B)

62	F5.3	265-269	AFORT1 - Available fortification Fe at a 1% absorption level (B&B)
63	F5.2	270-274	CNHIB - Calc'd nonheme iron for the Bull & Buss model
64	F4.2	275-278	ACNHIB - Available calc'd nonheme iron (B&B)
65	F5.2	279-283	VDNIB - Value derived (actual) nonheme iron, Bull & Buss
66	F4.2	284-287	AVDNIB - Available value derived nonheme iron, B&B

FILE: DAILYSRT.COLS

NOTE:

1) DAILYSRT.COLS1 is a file containing items 17-33 of the file DAILYSRT.DAT. It is formatted as documented under DAILYSRT.DAT.
2) DAILYSRT.COLS2 is a file containing items 34-48 of the file DAILYSRT.DAT. It is formatted as documented under DAILYSRT.DAT.
3) DAILYSRT.COLS3 is a file containing items 49-66 of the file DAILYSRT.DAT. It is formatted as documented under DAILYSRT.DAT.

FILE: DIETAVNTS.DAT

FORMAT:

ITEM	FORMAT	COLUMNS	CONTENTS
1	I5	1-5	I.D. # of subject
2	I2	6-7	Day # (0 = Avg of days eaten)
3	I2	8-9	Meal # (0 = Totals consumed per avg day)
4	I2	10-11	Total # of fds eaten/day
5	F10.3	12-21	Energy, kcal
6	F10.3	22-31	Protein, grams
7	F10.3	32-41	Fat, grams
8	F10.3	42-51	CHO, grams
9	F10.3	52-61	Crude fiber, grams
10	F10.3	62-71	Iron, mg
11	F10.3	72-81	Vit. C, Mg

FILE: DIET*F.DAT
NOTE: This file is read by DIETX2.FOR
FORMAT:

ITEM #	FORMAT	COL RANGE	CONTENTS
1	I3	1-3	Person I.D.
2	I2	4-5	Day #
3	I2	6-7	Meal #
	2X		Blank
4	I2	10-11	First digit is the school; the 2nd digit is grade
	3X		Blank
5	I1	15	Continuation code, blank or 0 is last card (or only card for this meal; 1 = there is at least 1 more card for this meal)
	2X		Blank
6	I4	18-21	Hdbk 8 food #
7	F3.0	22-24	Grams of the food cited
8-23	These are a repeat of items 6 & 7. Therefore 9 foods with wts are coded per record as a maximum		

FILE: DIETNUTS.DAT
NOTE:

1) File created by DIETX2.FOR when reading DIET*F.DAT and HB8MARY.DAT. Holds "just in case" items.
2) When reading this file use BLANK='ZERO' in open statement as I.D. may be NN NN or NN N etc.
3) For a person having 2 days of food coded (6 meals per day) this file will have 14 records/person (i.e values for each of 6 meals and then total amount for the day for Day 1 and the same for Day 2.

FORMAT:

ITEM	FORMAT	COLUMN	CONTENTS
1	I5	1-5	I.D. (1st digit = school, 2nd digit = grade, 3rd - 5th = person)
2	I2	6-7	Day #
3	I2	8-9	Meal # (0 - total for day)
4	I2	10-11	# foods in this meal (where meal = 0, = fds in day)
5	10.3	12-21	Kcal of energy, total, for this meal of the day
6	10.3	22-31	Grams of protein, total, for this meal of the day
7	10.3	32-41	Grams of fat, total, for this meal of the day
8	10.3	42-51	Grams of CHO, total, for this meal of the day
9	10.3	52-61	Grams of crude fiber, total,

			for this meal of the day
10	10.3	62-71	mg iron, total, for this meal of the day
11	10.3	72-81	mg Vitamin C, total, for this meal of the day

FILE: DIETRECOD.DAT

NOTE:

1) Format = (I3,2I1,5F8.3)
2) Has 4 records per person.
3) DIETRECOD.DAT is read by MODELFRC.COR.
4) DIETRECOD.DAT created REMAKE.FOR by using data in DIETAVNTS.DAT and MFPHEMAVE.DAT

FORMAT:

ITEM	FORMAT	CONTENTS
1	I3	I.D. #
2	I1	Day # (Should be 0; i.e the avg.day)
3	I1	Meal # (1 = breakfast; 2 = lunch; 3 = dinner; 4 = snacks)
4	F8.3	mg total Fe this meal; calc'd from % of avg daily totals
5	F8.3	mg total Vit. C this meal; calc'd from % of avg daily totals
6	F8.3	grams total MFP this meal; calc'd from % of avg daily totals
7	F8.3	mg total meat Fe this meal; calc'd from % of avg daily totals
8	F8.3	mg total heme iron this meal; calc'd from % of avg daily totals

FILE: DIETX2.FOR

NOTE: This documents all files Diet*F.Ext.

DIETX2.FOR reads:

LOGNAM - assign one of 4 Diet*F.dat files
HB8MARY.DAT - source of nutrient values for foods
HEMEVALGS.DAT - source of heme, meat iron and grams of meat, fish, poultry

DIETX2.FOR creates:

DIET.OUT - file to tell of bad data accessed
FOLLOW.RID - a proof-reader type of file
DIETNUTS.DAT
DIETAVNTS.DAT
MFPHEMETC.DAT
MFPHEMAVE.DAT

Variables in DIETX2.FOR:

No.	Name	Type	Meaning/Use
1.	HEME (4000,3)	R	Holds: 1.Heme iron value for a food # 2.Meat iron

			3. Percent meat in a food as a decimal %
2.	MCRAY (4000,2)	I	Meat Code Array. In spot 1 of 2 is the meat code. 1 is beef etc, 2 is pork etc. (Bull & Buss)
3.	NUM	I	Handbook 8 food #
4.	HEMEFE	R	mg of heme iron in a food
5.	MEATFE	R	mg of iron in the meat
6.	MTCODE	I	the meat type code (see Mcray)
7.	MEATG	R	Grams of meat in 100g food
8.	I.D.	I	Person # (3 digit)
9.	IDEX	I	Extra I.D. (2 digit) is School # & Grade #
10.	DYN	I	Day # (our data = 1 or 2)
11.	MLN	I	Meal # (our data = 1 to 6)
12.	CODE	I	A continuation code: 0 = last record this meal, 1 = more records this meal
13.	FDN (54)	I	Holds Hdbk 8 food #'s/meal
14.	GWT (54)	R	Holds wt of food in g/meal
15.	DAYS	I	Holds day # of day being processed
16.	IDEXSV	I	Holds extra I.D. of person being processed
17.	IDSAVE	I	Holds I.D. of person being processed
18.	WTBASIS	R	Wt basis for the nutrients in hdbk 8 (i.e. x mg Fe/y g food)
19.	VAL (7)	R	The nutrients used from hdbk 8:1 = Kcal, 5 = crude fiber, 6 = Fe, 7 = Vit. C
20.	NAME (54)	A	Holds 1 name for each food consumed at a meal
21.	FACTOR	R	The portion of a nutrient to use calc'd for each food
22.	MEAL (2,6,7)	R	The 2 = Day 1 or 2, 6 is for each of 6 meals, the 7 is for 7 nutrients consumed at each meal. Holds all nutrients consumed by day, meal for one person
23.	NAM	A	Holds temporarily, one food name.
24.	MEATG	R	Actual grams meat from this food consumed by this person.
25.	FCTR	R	The portion of the HEMEVALGS.DAT data or "item" consumed by this person from this food
26.	FACT	R	Amt. meat Fe from this amt.

			this food consumed by this person in this meal
27.	MFPM	R	Meat, Fish, Poultry Meat info. 2 is for Day 1 or 2; 6 for meal 1 to 6 & 7 for 1 = g meat type 1, 2 = g meat type 2, 3 total g meat, 4 = meat Fe type 1, 5 = meat Fe type 2, 6 = total meat iron, 7 = heme iron. Holds totals of all 7 items for each meal of day for this person.
28.	COUNT (6)	I	Hold counts of # fds consumed each of 6 meals
29.	DAYNUT (2,7)	R	Holds the 7 nutrients totaled for day 1 & 2
30.	DAYMFP (2,7)	R	Holds the 7 meat related items, totaled day 1 & 2
31.	TCOUNT	I	Total # fds consumed by this person for each of day 1 & 2
32.	MEALMAX	I	Max # meals allowed
33.	TOTMEAL (6,7)	R	Total of each of 7 nutrients in each of 6 meals for all days
34.	TOTMFPM (6,7)	R	Total of each of 7 meat type items in each of 6 meals for all days
35.	TOTNUTS (7)	R	Total of each of 7 nutrients consumed by this person
36.	TOTDAYMFP (7)	R	Total of each of 7 meat type items
37.	AVEMEAL (6,7)	R	Avg daily amt of each of 7 nutrients for 6 meals for this person
38.	AVEMFPM (6,7)	R	Avg daily amt of each of 7 meat type items for each of 6 meals for this person
39.	AVENUTS (7)	R	Avg total daily amt of each of 7 nutrients
40.	AVEDAYMFP	R	Avg total daily amt of each of 7 meat type items
41.	TC	I	Filler to replace space for total count with 0
42.	IDAY	I	Filler to replace Day # with 0 = avg day

FILE: FOURMEALS.DAT

NOTE:

1) FOURMEALS.DAT is a file of 4 meals (breakfast, lunch, dinner and snacks) and a total for the day. Thus, there

are 5 records per person. "Snacks" is a sum of 3 possible snacks in a day.
2) Data is derived from 6 other files.
3) This file is formatted as follows: (I5, I1, 2F6.2, 2I2, F5.0, 26F7.3, F6.3).
4) This also documents FOURMLSRT.DAT which is the same file as FOURMEALS.DAT but has been sorted in ascending order on mg Fe/1000 kcal.

FORMAT:

ITEM	FORMAT	COLUMNS	CONTENT
1	I5	1-5	I.D. #
2	I1	6	Meal #
[From HOLDSAHW.DAT (Dem1(2), Dem2(2))]			
3	F6.2	7-12	Height
4	F6.2	13-18	Weight
5	I2	19-20	Sex: 1 = Male, 2 = Female
6	I2	21-22	Age
[From DIETAVNTS.DAT (Nut(7,3))]			
7	F5.0	23-27	Kcal consumed
8	F7.3	28-34	Iron consumed
9	F7.3	35-41	Vitamin C consumed
[From MFPHEMAVE.DAT (MFP(7.3))]			
10	F7.3	42-48	grams MFP (meat, fish, poultry)
11	F7.3	49-55	mg of iron contained MFP
12	F7.3	56-62	mg heme iron
[From MDLEXTRA1.DAT (Val 3(6,6))]			
13	F7.3	63-69	Calc'd heme iron (Monsen)
14	F7.3	70-76	Available calc'd heme iron (Monsen)
15	F7.3	77-83	Enhancement factor (Monsen)
16	F7.3	84-90	Nonheme iron (Monsen)
17	F7.3	91-97	Available nonheme iron (Monsen)
18	F7.3	98-104	Total available iron for this meal (Monsen)
[From DIETRECOD.DAT (Val 4(4,5))]			
19	F7.3	105-111	Iron calculated using the general consumption pattern
20	F7.3	112-118	Vitamin C (GCP)
21	F7.3	119-125	g MFP (GCP)
22	F7.3	126-132	mg MFP iron (GCP)
23	F7.3	133-139	mg actual heme iron (GCP)
[From MDLP2EXTR.DAT (Val 5(4,10))]			
24	F7.3	140-146	Calc'd heme iron (GCP)
25	F7.3	147-153	Available calc'd heme iron (GCP)
26	F7.3	154-160	Enhancement factor (GCP)
27	F7.3	161-167	Nonheme iron, "calculated" or after Monsen's style, (GCP)
28	F7.3	168-174	Available nonheme iron "calculated" or after Monsen's style, (GCP).
29	F7.3	175-181	Total available iron this meal using calc'd heme values (GCP)
30	F7.3	182-188	Available heme iron using

			actual heme values derived from the literature (GCP)
31	F7.3	189-195	Nonheme iron (actual, GCP)
32	F7.3	196-202	Available nonheme iron (actual, GCP)
33	F7.3	203-209	Total available iron for this meal using actual values (GCP)
34	F6.3	210-215	mg Fe/1000 kcal

FILE: HB8MARY.DAT
NOTE: This file contains 4673 records and was created 5/16/84. It contains nutrient data from USDA Handbook #8 (USDA, 1963) in the following format:
FORMAT:

Columns	Item No.	Format	Contents
1-9	1	9.4	Weight basis
10-18	2	9.4	Weight of 1 serving
19-27	3	9.4	0 or Folacin
28-36	4	9.4	Water (grams)
37-45	5	9.4	Energy (kcal)
46-53	6	8.4	Protein (grams)
54-61	7	8.4	Fat (grams)
62-69	8	8.4	Total CHO
70-77	9	8.4	Crude fiber
78-85	10	8.4	Ash
86-95	11	10.4	Calcium
96-105	12	10.4	Phosporus
106-115	13	10.4	Iron
116-125	14	10.4	Sodium
126-135	15	10.4	Potassium
136-145	16	10.4	Vitamin A
146-152	17	7.4	Thiamin
153-159	18	7.4	Riboflavin
160-168	19	9.4	Niacin
169-177	20	9.4	Vitamin C
178-186	21	9.4	Sat fat
187-195	22	9.4	Monounsat fat
196-204	23	9.4	Polyunsat fat
205-213	24	9.4	Cholesterol
214-222	25	9.4	Food code
223-276	26	A (54 char)	Name
277-294	27	A (18 char)	Serving size
293-303	28	9.4	Pantothenic acid/Det.fiber (3000-3572)
304-312	29	9.4	Vitamin B6/Cu (3000-3572)
313-321	30	9.4	Vitamin B12/Zn (3000-3572)

FILE: MDLEXTRA1.DAT

NOTE:

1) Created by MODELS.FOR by reading DIETAVNTS.DAT and MFPHEMAVE.DAT.
2) These are just-in-case items.
3) This file has 6 records per person (i.e. no totals and is listed as breakfast, snack, lunch, snack, dinner, snack).
4) Records = 71.

FORMAT:

ITEM	FORMAT	COLUMNS	CONTENTS
1	I5	1-5	I.D. # - 1st digit is school, 2nd digit is grade, 3-5 digits is person I.D.
2	I2	6-7	Meal #
3	F8.3	8-15	CHF - Calc'd heme iron after Monsen model
4	F8.3	16-23	ACHF(I) - This meal's available calc'd heme iron
5	F8.3	24-31	EFM - This meal's enhancement factor
6	F8.3	32-39	FACT - This meal's value for $\log_e$ ((EFM + 100)/100)
7	F8.3	40-47	ABSP - Percent absorption of nonheme iron for this meal
8	F8.3	48-55	NONH(I) This meal's nonheme iron
9	F8.3	56-63	ANHF(I) This meal's available nonheme iron
10	F8.3	64-71	MAFE(I) This meal's total available iron

FILE: MDLEXTRA2.DAT

NOTE:

1) Created by MODELS.FOR by reading DIETAVNTS.DAT and MFPHEMAVE.DAT
2) Records = 286
3) This file holds just-in-case items.
4) This file contains 1 record per person.
5) Abbreviations used in this file are defined in the file MODELS.FOR. of this appendix.

FORMAT:

ITEM	FORMAT	COLUMNS	CONTENTS
1	I5	1-5	I.D.
2	F7.3	6-12	DCHF
3	F7.3	13-19	DACHF
4	F7.3	20-26	DNONH
5	F7.3	27-33	DANHF
6	F7.3	34-40	HFOC
7	F7.3	41-47	NONHOC
8	F7.3	48-54	AHFOC
9	I2	55-56	I, i.e. the # 1 which is the divisor for EFO and involved in

the next 4 variables.

10	F8.2	57-64	EFO(I) Enhancement factor One Large Meal divided by 1
11	F7.3	65-71	ABSPO(I) % absorption using above EFO
12	F7.3	72-78	ANHFOC(I) Available nonheme Fe one large meal from calc'd heme using above absorption
13	F7.3	79-85	ANHFOA(I) Available nonheme Fe one large meal from actual heme data (i.e values derived from the literature) using the above absorption
14	I2	86-87	I, 2, but here EFO(I) is divided by 3
15	F8.2	88-95	EFO(I)
16	F8.2	96-102	ABSPO(I)
17	F8.2	103-109	ANHFOC(I)
18	F8.2	110-116	ANHFOA(I)
19	I2	117-118	"I", 3 but here EFO(I) divided by 4
20	F8.2	119-126	EFO(I)
21	F7.3	127-133	ABSPO(I)
22	F7.3	134-140	ANHFOC(I)
23	F7.3	141-147	ANHFOA(I)
24	I2	148-149	"I", 4 but here EFO(I) divided by 5
25	F8.2	150-157	EFO(I)
26	F7.3	158-164	ABSPO(I)
27	F7.3	165-171	ANHFOC(I)
28	F7.3	172-178	ANHFOA(I)
29	I2	179-180	"I", 5 but here EFO(I) divided by 6
30	F8.2	181-188	EFO(I)
31	F7.3	189-195	ABSPO(I)
32	F7.3	196-202	ANHFOC(I)
33	F7.3	203-209	ANHFOA(I)
34	F7.3	210-216	NHFOA - Nonheme from one large meal using literature value heme (i.e. actual heme)
35	F7.3	217-223	AHFOA - Available heme, one large meal, using actual values
36	F7.3	224-230	CHIB - Calc'd heme iron, Bull & Buss
37	F7.3	231-237	ACHIB - Available calc'd heme iron, Bull & Buss
38	F7.3	238-244	FORT - 11% of dietary iron, or fortification iron, Bull & Buss
39	F7.3	245-251	AFORT - Available fortification iron at a 5% absorption level
40	F7.3	252-258	AFORT1 - Available fortification at a 1% absorption level
41	F7.3	259-265	CNHIB

42	F7.3	266-272	ACNHIB
43	F7.3	273-279	VDNIB
44	F7.3	280-286	AVDNIB

FILE: MFPHEMAVE.DAT

FORMAT:

ITEMS	FORMAT	COLUMNS	CONTENTS
1	I5	1-5	I.D. # of subject
2	I2	6-7	Day # (0 = Avg of days eaten)
3	I2	8-9	Meal # (0 = Totals consumed/avg. day)
4	F8.3	10-18	Grams of meat, fish, poultry (MFP) consumed per day of the type "A" or "1" variety (i.e beef, lamb, red meats, poultry)
5	F8.3	19-26	Grams of MFP consumed/day of the type "B" or "2" variety (i.e. pork, bacon ham, liver, fish)
6	F8.3	27-34	Total grams of MFP consumed per day
7	F8.3	35-42	Mg of Fe consumed/day of type "A" or "1" meat
8	F8.3	43-50	Mg of Fe consumed/day of type "B" or "2" meat
9	F8.3	51-58	Total meat iron consumed per day
10	F8.3	59-65	Mg of "actual" heme iron consumed per day

FILE: MFPHEMETC.DAT

NOTE:

1) File created by DIETX2.FOR for reading DIET*F.DAT and HEMEVALGS.DAT. Holds "just in case" items.

2) When reading this file use BLANK = 'ZERO' in open statemaent because the IDs are being put out as NN N or NNNNN.

3) For a person who has 2 days of six meals each coded, there will be 14 records per person: 1-6 records, Day 1, Meals 1-6, totals each item for a meal; 7 record Day 1 Meal 0, totals each item for the day. This is repeated for Day 2.

4) Records = 65

5) MFP = meat, fish, poultry

6) Type "A" meat = beef, lamb, red meats, poultry and type "B" = pork, bacon, ham, liver, fish

FORMAT:

ITEM	FORMAT	COLUMNS	CONTENTS
1	I5	1-5	I.D. for this person

2	I2	6-7	Day #
3	I2	8-9	Meal # (Meal = 0 is for the total for this day)
4	F8.3	10-17	G MFP type "A" for this meal this day
5	F8.3	18-25	G MFP type "B" for this meal this day
6	F8.3	26-33	G MFP - all MFP
7	F8.3	34-41	mg iron from type "A" MFP for this meal this day
8	F8.3	42-49	mg iron from type "B" MFP for this meal this day
9	F8.3	50-57	mg iron from all MFP
10	F8.3	58-65	mg heme iron this meal this day

FILE: MODELS.FOR

FORMAT:

VARIABLE NAME	ITEM NO.	CONTENTS
I.D.(I)	1	
DAY (I)	2	
MEAL (I)	3	Meal
VAL (7,7) (R)	4	Value contains 7 records of DIETAVNTS.DAT. The first 7 references are meal 1-6 + 0 (total). The 2nd references nutrients data for that meal: 1=kcal, 2=prot, 3=fat, 4=CHO, 5=crude fiber, 6=Fe, 7=Vit C
MFPS (7,7) (R)	5	Meat Fish Poultry Stuff & contains: first 7 references, meals 1-6 + 0 (total). The 2nd references: 1= G MFP type "A", 2= G MFP type "B", 3= G MFP total, 4= mg Fe from type "A", 5= mg Fe from type "B" MFP, 6= mg Fe from all MFP, 7= mg heme Fe. This array contains 7 records of MFPHEMAVE.DAT
IDSAVE (I)	6	I.D. saved so have record of ID just processed
CHF (6) (R)	7	Calc'd heme Fe, after Monsen's Model for each of 6 meals
DCHF (R)	8	Daily calc'd heme Fe holds one avg day or 6 meals
ACHF (R)	9	Avail calc'd heme Fe from Monsen's model
DACHF (R)	10	Daily avail calc'd heme Fe - total 6 meal of ACHF
EFM (R)	11	Enhancement factor after

		Monsen Model
FACT (R)	12	Factor for internal step in obtaining absorption
ABSP (R)	13	Absorption value as a % from Monsen
NONH (6) (R)	14	Nonheme iron after Monsen for each of 6 meals
DNONH (R)	15	Daily nonheme iron totaling 6 meals of NONH
ANHF (6) (R)	16	Avail nonheme Fe after Monsen for each of 6 meals
DANHF (R)	17	Daily avail nonheme Fe totals ANHF for 1 day
MAFE (6) (R)	18	Meal avail Fe after Monsen for each of 6 meals. Sum of ACHF (6) & ANHF (6)
TAFE (R)	19	Total avail Fe; daily total avail iron sums six meals.
GCP (6,5) (R)	20	General consumption pattern contains the % of each of 5 components for each of 6 meals in a decimal form: 6 is for 6 meals; 5 is for 1= % Fe, 2= % Vit C, 3= % actual heme, 4=% meat iron (MFP), 5= % meat, fish, poultry (grams). The GCP is percent of the daily totals
HFOC (R)	21	Heme Fe one large meal - calc'd
NONHOC (R)	22	Nonheme iron one large meal - calc'd - using Monsen style
AHFOC (R)	23	Avail heme Fe one large meal - calc'd - using Monsen style
AHFOA (R)	24	Avail heme Fe one large meal - actual (0.23 * Heme data). Actual means using literature heme data
NHFOA (R)	25	Nonheme Fe, one large meal, actual
EFO (5) (R)	26	Enhancement factor for one large meal; adapted Monsen style: EFO (1) = Enhancement factor/1; (2) = EF/3; (3) = EF/4; (4) = EF/5 (5) = EF/6
ABSPO (5) (R)	27	Absorption factor one large meal - as a % each based on a EFO (5)
ANHFOC (5) (R)	28	Avail nonheme Fe one large meal calc'd (i.e. using calcd heme iron to get nonheme iron) and appropriate EFO (5)
TAFOC (5) (R)	29	Total available Fe one large meal calc'd (i.e. after Monsen style of calculating and using appropriate EFO (5)
ANHFOA (5) (R)	30	Available nonheme Fe one large meal actual - determing avail

		with appropriate EFO (5)
TAFOA (5) (R)	31	Total available Fe one large meal actual; Sum ANHFOA & AHFOA
CHIB (R)	32	Calc'd heme iron, Bull & Buss
ACHIB (R)	33	Available calc'd heme iron, Bull Buss
FORT (R)	34	Fortification iron after Bull & Buss (i.e. estimated amt of iron in diet from fortified source)
AFORT (R)	35	Avail fortification using 5% absorption
AFORT1 (R)	36	Avail fortified iron usin 1% absorption
CNHIB (R)	37	Calc'd nonheme iron after Bull Buss
ACNHIB (R)	38	Available calc'd nonheme iron after Bull & Buss
TACIB (R)	39	Total avail calc'd nonheme iron after Bull & Buss using 5% absorption for fortified iron
TACIB1 (R)	40	Total avail calc'd nonheme iron after Bull & Buss using 1% absorption for fortified iron
VDNIB (R)	41	Value derived nonheme iron after Bull and Buss (i.e. using values derived from literature for heme, also known as "actual" heme)
AVDNIB (R)	42	Available value derived nonheme iron after Bull & Buss
TAVDIB (R)	43	Total avail value derived iron after Bull & Buss using avail fort iron at 5% level
TAVDIB1 (R)	44	Total avail value derived iron after Bull & Buss using fortified iron absorped at 1% level
KCAL (R)	45	Avg daily kcal for this person

FILE: MODELSP1.DAT

NOTE:

1) Name of file means "models phase one data".
2) Created by MODELS.FOR while reading DIETAVNTS.DAT and MFPHEMAVE.DAT.
3) Has one record per person.
4) Has 312 records.
5) Definitions for the abbreviations used in this file may be found in the file MODELS.FOR of this appendix.

FORMAT

ITEM	FORMAT	COLUMNS	CONTENTS
1	I5	1-5	I.D.
2	F6.3	6-11	TAFE - total avg daily avail Fe - Monsen model
3	F7.0	12-18	Kcal - total daily energy

4	F6.2	19-24	EFO (1)
5	F6.2	25-30	EFO (2)
6	F6.2	31-36	EFO (3)
7	F6.2	37-42	EFO (4)
8	F6.2	43-48	EFO (5)
9	F6.3	49-54	TAFOC (1)
10	F6.3	55-60	TAFOC (2)
11	F6.3	61-66	TAFOC (3)
12	F6.3	67-72	TAFOC (4)
13	F6.3	73-78	TAFOC (5)
14	F6.3	79-84	TAFOA (1)
15	F6.3	85-90	TAFOA (2)
16	F6.3	91-96	TAFOA (3)
17	F6.3	97-102	TAFOA (4)
18	F6.3	103-108	TAFOA (5)
19	F6.3	109-114	TACIB
20	F6.3	115-120	TAVDIB
21	F6.3	121-126	TACIB1
22	F6.3	127-132	TAVDIB1
23	F6.3	133-138	GCP for the % of Fe for meal 1
24	F6.3	139-144	GCP for the % of Fe for meal 2
25	F6.3	145-150	GCP for the % of Fe for meal 3
26	F6.3	151-156	GCP for the % of Fe for meal 4
27	F6.3	157-162	GCP for the % of Fe for meal 5
28	F6.3	163-168	GCP for the % of Fe for meal 6
29	F6.3	169-174	GCP for the % Vit. C, meal 1
30	F6.3	175-180	GCP for the % Vit. C, meal 2
31	F6.3	181-186	GCP for the % Vit. C, meal 3
32	F6.3	187-192	GCP for the % Vit. C, meal 4
33	F6.3	193-198	GCP for the % Vit. C, meal 5
34	F6.3	199-204	GCP for the % Vit. C, meal 6
35	F6.3	205-210	GCP for % actual heme, meal 1
36	F6.3	211-216	GCP for % actual heme, meal 2
37	F6.3	217-222	GCP for % actual heme, meal 3
38	F6.3	223-228	GCP for % actual heme, meal 4
39	F6.3	229-234	GCP for % actual heme, meal 5
40	F6.3	235-240	GCP for % actual heme, meal 6
41	F6.3	241-246	GCP for % MFP iron, meal 1
42	F6.3	247-252	GCP for % MFP iron, meal 2
43	F6.3	253-258	GCP for % MFP iron, meal 3
44	F6.3	259-264	GCP for % MFP iron, meal 4
45	F6.3	265-270	GCP for % MFP iron, meal 5
46	F6.3	271-276	GCP for % MFP iron, meal 6
47	F6.3	277-282	GCP for % MFP grams, meal 1
48	F6.3	283-288	GCP for % MFP grams, meal 2
49	F6.3	289-294	GCP for % MFP grams, meal 3
50	F6.3	295-300	GCP for % MFP grams, meal 4
51	F6.3	301-306	GCP for % MFP grams, meal 5
52	F6.3	307-312	GCP for % MFP grams, meal 6

FILE: MODELSP2.DAT

NOTE:

1) Created by MODELFRC.FOR reading DIETRECOD.DAT

2) Format (I5,2F7.3)

FORMAT:

ITEM	FORMAT	COLUMN	CONTENTS
1	I3	1-3	I.D.
2	F7.3	4-10	mg nonheme iron

FILE: SIXMEALS.DAT

NOTE:

1) This is a file of six meals (i.e. breakfast, snack, lunch, snack, dinner, snack) plus a total. Thus, there are 7 records per person.

2) Meal = 0 is the total for the day.

3) The data is derived from four files.

4) This file is formatted as follows: (I5, I1, 2F6.2, 2I2, F5.0, 11F7.3, F6.3).

5) This also documents SIXMLSRT.DAT which is the same file as SIXMEALS.DAT but has been sorted in ascending order on mg Fe/1000 kcal.

FORMAT:

ITEM	FORMAT	COLUMNS	CONTENT
1	I5	1-5	I.D. #
2	I1	6	Meal
[From HOLDSAHW.DAT (Dem1(2), Dem2(2))]			
3	F6.2	7-12	Height
4	F6.2	13-18	Weight
5	I2	19-20	Sex
6	I2	21-22	Age
[From DIETAVNTS.DAT (Nut(7,3))]			
7	F5.0	23-27	Kcal (Monsen)
8	F7.3	28-34	Iron (Monsen)
9	F7.3	35-41	Vitamin C (Monsen)
[From MFPHEMAVE.DAT (MFP(7,3))]			
10	F7.3	42-48	g MFP (Monsen)
11	F7.3	49-55	mg MFP iron (Monsen)
12	F7.3	56-62	mg Heme iron (Monsen)
[From MDLEXTRA1.DAT (Val3 (6,6))]			
13	F7.3	63-69	Calc'd heme iron (Monsen)
14	F7.3	70-76	Available calc'd heme iron (Monsen)
15	F7.3	77-83	Enhancement factor (Monsen)
16	F7.3	84-90	Nonheme iron (Monsen)
17	F7.3	91-97	Available nonheme iron (Monsen)
18	F7.3	98-104	Total available iron this meal (Monsen)
19	F6.3	105-110	mg Fe/1000 kcal

Appendix D: Steps Used in Running the Statistical Programs

Introduction

Given below are the exact step by step methods used to compute the statistics of this project. All details are given in the event further research is done on this work.

Computer Files

All files used to generate the models and those files created in running the statistical analyses have been saved on a computer tape, named "Darks". The exact contents of all files are listed in Appendix E. The final computer files, with brief descriptions, generated from determining the models, are as follows:

1) Dailys.dat which contains daily totals for 70 nutrients and other dietary components consumed by the 737 subjects. This file contains the daily totals of nutrients consumed (i.e. carbohydrate, protein etc.); of the grams of meat, fish, poultry consumed; of enhancement factors consumed as determined by each model; of nonheme/heme iron as determined by each model. This file also contains demographic data (i.e. height, weight etc.) for each subject. Dailysrt.dat was an additional file created. It contained the same information as Dailys.dat but was sorted from low to high based on iron density.
2) Fourmeals.dat which is a file of 5 records per person consisting of nutrient and other dietary component totals for breakfast, lunch, dinner, snacks and a total for the day. "Snacks" is a sum of all snacks consumed by the subjects. Fourmeals.dat contains the above records as determined by the Monsen method as well as the General Consumption Pattern. Fourmlsrt.dat was an additional file created. It contained the same information as Fourmeals.dat but was sorted from low to high based on iron density.
3) Sixmeals.dat which is a file of 7 records per person consisting of nutrient and other dietary component totals for breakfast, snack, lunch, snack, dinner, snack and a total for the day as consumed for each subject. This file contains actual nutrient data (i.e kcal consumed per meal/snack etc.) and "iron" data (i.e. the amount of heme iron consumed per meal/snack as determined by Monsen's method). Sixmlsrt.dat was an additional file created. It contained the same information as Sixmeals.dat but was sorted from low to high based on iron density.

However, to run the various statistical analyses the form of the final three files had to be reworked, using various Fortran programs, and generating several new files which are also documented in Appendix E.

Statistical Analysis

Introduction. In general, statistical analyses was run on the final three files using three separate computer oriented statistical packages. First, analysis of variance comparing variables whose values were generated by the Monsen method to variables whose values were generated by the General Consumption Pattern were run using the Minitab Statistical Package (BYU 1983). Minitab was also used to obtain observed means (i.e. true means), standard deviations, medians, minimum/maximum figures on the meal values generated by the General Consumption Pattern and the Monsen method. Minitab was then used to obtain the true means, standard deviations, medians, minimum/maximum values on the daily totals of the 66 nutrients and other dietary components listed in the computer file "Dailys.dat" (See Appendix E for exact listing of the nutrients). Secondly, using the Rummage statistical package (BYU, 1983), the analysis of variance comparisons, broken down by sex and by density (i.e six cells), between the control and the three proposed models, as well as comparisons between the models themselves were run on five variables: total available iron, heme iron, nonheme iron, available heme iron and available nonheme iron. Finally, the SPSSX statistical package (SPSSX, 1983) was used to obtain the observed means on the 70 nutrients and other dietary components listed in the computer file "Rummage.dat" (See Appendix E for exact listing of the nutrients). The methods used to run each individual statistical program will be discussed in greater detail in the following paragraphs.

Minitab. The computer file Fourmeals.dat, containing data generated by the Monsen method and by the General Consumption pattern, was sorted by iron density giving the file Fourmlsrt.dat. Fourmlsrt.dat was then divided by the public Vax program "Public Columns" into four computer files of a more managable size since Minitab will only run on files of 80 columns or less. The four new files created were Frothl.col (containing items 7-12 of Fourmlsrt.dat), Fourmon.col (containing items 13-18 of Fourmlsrt.dat), Froth2.col (containing items 19-23 of Fourmlsrt.dat), and Fourgcp.col (containing items 24-33 of Fourmlsrt.dat). Exact contents of all files are documented in Appendix E. Fourmon.col and Fourgcp.col were analyzed by one way analysis of variance, using Minitab (BYU, 1985), comparing each nutrient or dietary component contained in the file generated by the Monsen method to its counterpart generated by the General Consumption pattern. The files Xachm.aov, However, to run the various statistical analyses the form of the final three files had to be reworked, using various Fortran programs, and generating several new files which are also documented in Appendix E. This will be discussed in further detail in the following section.

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Introduction. In general, statistical analyses was run on the final three files using three separate computer oriented statistical packages. First, analysis of variance comparing variables whose values were generated by the Monsen method to variables whose values were generated by the General Consumption Pattern were run using the Minitab Statistical Package (BYU 1983). Minitab was also used to obtain observed means (i.e. true means), standard deviations, medians, minimum/maximum figures on the meal values generated by the General Consumption Pattern and the Monsen method. Minitab was then used to obtain the true means, standard deviations, medians, minimum/maximum values on the daily totals of the 66 nutrients and other dietary components listed in the computer file "Dailys.dat" (See Appendix E for exact listing of the nutrients). Secondly, using the Rummage statistical package (BYU, 1983), the analysis of variance comparisons, broken down by sex and by density (i.e six cells), between the control and the three proposed models, as well as comparisons between the models themselves were run on five variables: total available iron, heme iron, nonheme iron, available heme iron and available nonheme iron. Finally, the SPSSX statistical package (SPSSX, 1983) was used to obtain the observed means on the 70 nutrients and other dietary components listed in the computer file "Rummage.dat" (See Appendix E for exact listing of the nutrients). The methods used to run each individual statistical program will be discussed in greater detail in the following paragraphs.

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The files Frothl.col and Froth2.col were also analyzed by Minitab. The files Frothl.avg, Frothlx.avg, Frothx.avg, Froth2.avg and Frothxx.avg contain the output of these analyses, which includes the mean, median, standard deviation, minimum and maximum values for the variables of height; weight; age; kcal consumed; iron consumed; vitamin C consumed; grams of meat, fish, poultry consumed; mg of meat, fish, poultry iron consumed and mg of heme iron consumed at breakfast, at lunch, at dinner, and at the combined snack. Exact contents of all files are documented in Appendix E. The files Frotht.aov, Frothb.aov, Frothl.aov, Frothd.aov and Froths.aov also contain the mean, median, standard deviation, minimum and maximum values for the variables of iron, vitamin C, grams of meat, fish, poultry; mg of meat, fish, poultry iron consumed and mg of heme iron at breakfast, at lunch, at dinner, and at the combined snack as generated by the Monsen model and the General Consumption Pattern. However, in addition these files contain the oneway analysis of variance between each nutrient or dietary component, described above, generated by the Monsen model and its counterpart generated by the General Consumption Pattern. Exact contents of all files are documented in Appendix E. The public VAX program "Public Columns" was also used to break the file Dailys.srt into three smaller files; Dailysrt.cols1, Dailysrt.cols2, Dailysrt.cols3, so that Minitab could be used to analyze this data. Minitab was used to obtain the true means, standard deviations, medians, minimum/maximum values on the daily totals of the 66 nutrients and other dietary components listed in the computer file "Dailys.dat", although actual analsis took place on the three smaller files. The output of these Minitab runs are contained in the files Dailymeans.dat1, Dailymeans.dat2, Dailymeans.dat3 and Dailymeans.dat4. Exact listing of the components of each file is contained in Appendix E.

Total available iron (17 trails) as calculated by the Monsen method and by the three proposed models were analyzed by oneway analysis of variance using Minitab. The results of this analysis are given in the file Aovtafex.out.

The public VAX program "Public Columns" was also used to break the file Sixml.srt into two smaller files; Sixmlsrt.col1, and Sixmlsrt.col2 so that Minitab could be used to analyze this data. Minitab was used to obtain the true means, standard deviations, medians, minimum/maximum values of the nutrients and other dietary components of the three snacks of the file Sixmlsrt.dat, although actual analsis took place on the two smaller files. This constitutes analysis of the actual snacks eaten rather than an analysis of a "combined snack" (i.e. all snacks taken together). The output of these Minitab runs are contained in the files Sixml1s.avg, Sixml2s.avg, and Sixml3s.avg. Exact contents of each file are documented in Appendix E.

Rummage. Data from the computer files Fourmlsrt.dat and Dailysrt.dat were combined to form the file Datman.tot. Datman.tot contains 69 nutrients and other dietary components. These are documented in Appendix E. In general, Datman.tot contains:

1) Demographic data such as age, height, weight etc. of the subject.
2) The amount of heme iron "consumed" by each subject as calculated using the different models. In the case of heme iron this produced 7 different ways to calculate heme iron. See previous paragraphs in this Appendix for further clarification of the terms used. Also in parenthesis after each description is included the abbreviation used to for this value. These abbreviations were changed from those used in generating the models and in the "final files". These changes have been documented in Appendix E under the Datman.tot file. Therefore the 7 different types of heme iron include:
   a) Heme iron calculated as is done in the Monsen model. (HMCM1)
   b) Heme iron calculated by the one large meal model using "calculated" (i.e. 40% of the total iron is equal to the heme iron consumed) heme values. (HMCO2)
   c) Heme iron calculated by the method of Bull & Buss using "calculated" heme values. (HMCB3)
   d) Heme iron calculated by the general consumption pattern using "calculated" heme values. (HMCG4)
   e) Heme iron calculated by the one large meal model using "actual" or "value derived" (i.e. using actual heme iron values derived from the literature) heme values. (HMVDO5)
   f) Heme iron calculated by the method of Bull & Buss using "actual" heme values. (HMVDB6)
   g) Heme iron calculated by the general consumption pattern using "actual" heme values. (HMVDG7)
3) The amount of nonheme iron "consumed" by each subject as calculated using the different models. In the case of nonheme iron this produced 7 different ways to calculate nonheme iron. See previous paragraphs in this Appendix for further clarification of the terms used. These 7 different types of nonheme iron are as follows (including their abbreviations in parenthesis):
   a) Nonheme iron calculated as is done in the Monsen model. (NHCM1)
   b) Nonheme iron calculated by the one large meal

model using "calculated" (i.e. 40% of the total meat, fish, poultry iron consumed, is equal to the heme iron consumed) heme values. (NHCO2)

c) Nonheme iron calculated by the method of Bull & Buss using "calculated" heme values. (NHCB3)
d) Nonheme iron calculated by the general consumption pattern using "calculated" heme values. (NHCG4)
e) Nonheme iron calculated by the one large meal model using "actual" or "value derived" (i.e. using actual heme iron values derived from the literature) heme values. (NHVDO5)
f) Nonheme iron calculated by the method of Bull & Buss using "actual" heme values. (NHVDB6)
g) Nonheme iron calculated by the general consumption pattern using "actual" heme values. (NHVDG7)

4) The amount of available heme iron "consumed" by each subject as calculated using the different models. In the case of available heme iron this produced 7 different ways to calculate available heme iron. See previous paragraphs in this Appendix for further clarification of the terms used. These 7 different types of available heme iron are as follows, (including their abbreviations in parenthesis):
a) Available heme iron calculated as is done in the Monsen model. (AVHCM1)
b) Available heme iron calculated by the one large meal model using "calculated" (i.e. 40% of the total iron is equal to the heme iron consumed) heme values. (AVHCO2)
c) Available heme iron calculated by the method of Bull & Buss using "calculated" heme values. (AVHCB3)
d) Available heme iron calculated by the general consumption pattern using "calculated" heme values. (AVHCG4)
e) Available heme iron calculated by the one large meal model using "actual" or "value derived" (i.e. using actual heme iron values derived from the literature) heme values. (AVHVDO5)
f) Available heme iron calculated by the method of Bull & Buss using "actual" heme values. (AVHVDB6)
g) Available heme iron calculated by the general consumption pattern using "actual" heme values. (AVHVDG7)

5) The amount of available nonheme iron "consumed" by each subject as calculated using the different models. In the case of available nonheme iron this produced 15 different ways to calculate available nonheme iron. See previous paragraphs in this Appendix for further clarification of the terms used. These 15 different types of available nonheme iron are as follows (including their abbreviations in parenthesis):
a) Available nonheme iron calculated as is done in

the Monsen model. (In all statistical analyses this is referred to as ANHCM1).

b) Available nonheme iron derived from the one large meal model using "calculated" (i.e. 40% of the total meat, fish, poultry iron consumed, is equal to the heme iron consumed) heme values and enhancement factors divided by 1 (see previous paragraphs for further clarification of method and terms used). (ANHC012)

c) Available nonheme iron derived from the one large meal model using "calculated" heme values and enhancement factors divided by 3. (ANHC023)

d) Available nonheme iron derived from the one large meal model using "calculated" heme values and enhancement factors divided by 4. (ANHC034)

e) Available nonheme iron derived from the one large meal model using "calculated" heme values and enhancement factors divided by 5. (ANHC045)

f) Available nonheme iron derived from the one large meal model using "calculated" heme values and enhancement factors divided by 6. (ANHC056)

g) Available nonheme iron calculated by the method of Bull & Buss using "calculated" heme values. (ANHCB7)

h) Available nonheme iron calculated by the general consumption pattern using "calculated" heme values. (ANHCG8)

i) Available nonheme iron calculated by the one large meal model using "actual" or "value derived" (i.e. using actual heme iron values derived from the literature) heme values and enhancement factors divided by 1 (see previous section for further clarification of method and terms used). (ANVD019)

j) Available nonheme iron calculated by the one large meal model using "actual" or "value derived" heme values and enhancement factors divided by 3. (ANVD0210)

k) Available nonheme iron calculated by the one large meal model using "actual" or "value derived" heme values and enhancement factors divided by 4. (ANVD0311)

l) Available nonheme iron calculated by the one large meal model using "actual" or "value derived" heme values and enhancement factors divided by 5. (ANVD0412)

m) Available nonheme iron calculated by the one large meal model using "actual" or "value derived" heme values and enhancement factors divided by 6. (ANVD0513)

n) Available nonheme iron calculated by the method of Bull & Buss using "actual" heme values. (ANVDB14)

o) Available nonheme iron calculated by the general consumption pattern using "actual" heme values. (ANVDG15)

6) The amount of total available iron "consumed" by each subject as calculated using the different models. In the case of total available iron this produced 17 different ways to calculate total available iron. See previous paragraphs in this Appendix section for further clarification of the terms used. These 17 different types of total available iron are as follows (including their abbreviations in parenthesis):
   a) Total available iron calculated as is done in the Monsen model. (In all statistical analysis this is referred to as TAFM1).
   b) Total available iron derived from the one large meal model using "calculated" (i.e. 40% of the total meat, fish, poultry iron consumed is equal to the heme iron consumed) heme values and enhancement factors divided by 1 (see previous section for further clarification of method and terms used). (TAFC012)
   c) Total available iron derived from the one large meal model using "calculated" heme values and enhancement factors divided by 3. (TAFC023)
   d) Total available iron derived from the one large meal model using "calculated" heme values and enhancement factors divided by 4. (TAFC034)
   e) Total available iron derived from the one large meal model using "calculated" heme values and enhancement factors divided by 5. (TAFC045)
   f) Total available iron derived from the one large meal model using "calculated" heme values and enhancement factors divided by 6. (TAFC056)
   g) Total available iron calculated by the method of Bull & Buss using "calculated" heme values and considering 5% of all fortification iron to be absorbable. (TAFCB57)
   h) Total available iron calculated by the method of Bull & Buss using "calculated" heme values and considering 1% of all fortification iron to be absorbable. (TAFCB18)
   i) Total available iron calculated by the general consumption pattern using "calculated" heme values. (TAFCG9)
   j) Total available iron calculated by the one large meal model using "actual" or "value derived" (i.e. using actual heme iron values derived from the literature) heme values and enhancement factors divided by 1 (see previous section for further clarification of method and terms used). (TAVD0110)
   k) Total available iron calculated by the one large meal model using "actual" or "value derived" heme values and enhancement factors divided by 3. (TAVD0211)
   l) Total available iron calculated by the one large meal model using "actual" or "value derived" heme values and enhancement factors divided by 4. (TAVD0312)

m) Total available iron calculated by the one large meal model using "actual" or "value derived" heme values and enhancement factors divided by 5. (TAVD0413)

n) Total available iron calculated by the one large meal model using "actual" or "value derived" heme values and enhancement factors divided by 6. (TAVD0514)

o) Total available iron calculated by the method of Bull & Buss using "actual" heme values and considering 5% of all fortification iron to be absorbable. (TAVDB515)

p) Total available iron calculated by the method of Bull & Buss using "actual" heme values and considering 1% of all fortification iron to be absorbable. (TAVDB116)

q) Total available iron calculated by the general consumption pattern using "actual" heme values. (TAFVDG17)

Datman.tot was sorted by sex and density and the Manova procedure of the SPSSX statistical package was run on five variables: heme iron, nonheme iron, available heme iron, available nonheme iron, and total available iron. This procedure was run to obtain analysis of variance amoung the methods for each variable, by sex by density, and to obtain pairwise comparisons of the estimated means involved. However, the SPSSX program was found to have a "bug" in the Manova procedure and this attempt at analysis had to be discontinued. As a result it was decided to use the Rummage statistical package to obtain the above mentioned analysis of variance for each of the five variables but before this could be accomplished the data had to be reworked so that it was in the form of cells (i.e sex by density) on which the statistical analysis would be run. Therefore, Rummage became the second statistical package used to analyze this data.

In order for the data contained in the computer file Datman.tot to be in a workable form it underwent the following transformations:

1) The entire file Datman.tot was sorted by sex and by density becoming the file Datman.srt.
2) By running the Fortran program "ID.for" on the Datman.srt file, the file Rummage.dat was created. Rummage.dat contains the same data as Datman.srt but a new column of data was added to this file which was previously not contained in DATMAN.SRT. This new column of data is "new density" and was created by recoding the "old iron density" (i.e mg Fe per 1000 kcal consumed) into the following categories:
   a) 0-5.999 mg Fe/1000 kcal consumed = 1 (Low)
   b) 6-8.999 mg Fe/1000 kcal consumed = 2 (Medium)
   c) 9 or greater mg Fe/1000 kcal = 3 (High)

Also, Rummage.dat differs from Datman.srt in that it has been sorted into six "cells" by sex and by new density, (sex number 1 is male and sex number 2 is female). These cells are as follows: 1,1; 1,2; 1,3; 2,2; 2,2; 2,3. The cells contain the following number of subjects:

	Density (New Density)		
	1 (Low)	2 (Med.)	3 (High)
Sex			
1 (Male)	165	155	35
2 (Female)	176	172	34

3) The data of Rummage.dat, however, was still not in a form which the Rummage anova procedure could be used because the method used in each case had not been coded by number into the data, rather the method had been implied by the abbreviation used. As a result, four files, Meth15.dat, Meth6.dat, Meth7.dat, Meth17.dat, were created from Rummage.dat by the SPSSX command file "Rmdatdat.com". The newly created files contained each "cell" of the Rummage.dat file plus a newly created method number code. The key to the method number code is given in Appendix E under the names of these files. However, each file contained the data for one or two variables only. Meth6.dat contains data concerning heme and available heme iron. Meth7.dat contains data concerning nonheme iron. Meth15.dat contains data concerning available nonheme iron. Meth17.dat contains data concerning total available iron.
4) The Rummage anova procedure could still not be run because it was found that the "cells" of the Meth15.dat, Meth6.dat, Meth7.dat, Meth17.dat, files contained too many subjects. As a result, using the SPSSX statistical package, six new files were created from each Meth.dat file. These new files (i.e. Meth151.dat, Meth152.dat, Meth153.dat, Meth154.dat, Meth155.dat, Meth156.dat) each contain one "cell" (i.e. new density 1, sex 1), with 99 or fewer subjects, and were created by the SPSSX command files Sammth15.com, Sammth17.com, Sampmth6.com, Sampmth7.com. The number of subjects in each cell were reduced using a random sampling procedure of the SPSSX statistical package wherein a percent of the total is taken. The procedure was repeated on each file; Meth15.dat, Meth6.dat, Meth7.dat, Meth17.dat. Each contain different randomly sampled subjects for a total of 451 subjects of the original 737 subjects. The percents used were arbitrarily chosen to obtain cell sizes of around 99 subjects for each cell except for cells #3,1 and cell #3,2 which contained less than 99 subjects originally. After each of these individual files containing one cell were created (i.e. Meth151.dat, Meth152.dat, Meth153.dat, Meth154.dat, Meth155.dat, Meth156.dat) they were combined into one large file (i.e

Meth151.dat to Meth156.dat were combined to form Meth15.dt and Meth61.dat to Meth66.dat were combined to form Meth6.dt). The files created from this procedure were Meth6.dt, Meth7.dt, Meth17.dt, Meth15.dt. Meth6.dt contains ID number, method code, sex code, and the amount of heme iron and available heme iron "consumed" as generated by the 6 of the 7 methods, described previously when discussing the file Datman.tot. Only 6 of the 7 methods, with regard to heme and available heme iron, are used in this file because the one large meal method using value derived (i.e. actual) heme values produced the same values for heme and available heme iron as did the Bull & Buss method using value derived (i.e. actual) heme values. Thus, it was appropriate to only use these values once. Meth6.dt is arranged into six cells sorted by sex and by density with the following number of subjects in each cell:

	Density (New Density) 1 (Low)	2 (Med.)	3 (High)
Sex			
1 (Male)	99	97	35
2 (Female)	88	98	34

Meth7.dt, Meth15.dt, Meth17.dat are arranged identically to Meth6.dt. However, in Meth7.dat the variable of interest is nonheme iron as generated by 7 methods (see the discussion previously with regard to the Datman.tot file); in Meth15.dt the variable of interest is available nonheme iron as generated by 15 methods; in Meth17.dat the variable of interest is total available iron as generated by 17 methods.

5) The Rummage anova procedure, however, still would not run on the Meth6.dt, Meth7.dt, Meth15.dt, Meth17.dt files until each possessed sequential subject I.D. numbers. Please note the subject I.D. numbers were not sequential since they had been randonly sampled to decrease the number of subjects per cell. As a result the Fortran programs Newid15.for, Newid17.for, Newid6.for, Newid7.for were created and run on the files Meth6.dt, Meth7.dt, Meth15.dt, Meth17.dt. Sequential subject I.D. numbers were obtained in each cell. The newly created files were named Meth6.dt2, Meth7.dt2, Meth15.dt2, Meth17.dt2.

After all the preceding transformations were completed on the data the Rummage command files, Rummth15.com, Rummth6.com, Rummth7.com, and Rummth17.com were created. These command files allowed analysis of variance between the methods for each variable (i.e heme, nonheme, available heme, available nonheme and total available iron) as well as pairwise comparisons to be run. The outputs of the analyses are contained in the file Rummth15.out, Rummth17.out, Rummth6.out, and Rummth7.out. It should be reiterated that these statistical procedures (i.e. the Rummage procedures) were run on 451 subjects of the original 737 subjects. Also the analysis on each variable (i.e. heme, nonheme, available nonheme, available heme and total available iron) was run on a different randomly sampled set of 451 subjects of the original 737 subjects. All other statistical procedures (i.e. the Minitab and SPSSX procedures) were run on all of the original 737 subjects.

In addition Rummage was used to obtain analysis of variance, broken by sex, and by density, on calculated heme; nonheme; total available iron; height; weight; age; kcal; protein; fat; carbohydrate; crude fiber; iron; vitamin C; grams of meat, fish, poultry consumed; and "actual" heme consumed. Least significant comparisons were also run on the above mentioned nutrients and other dietary components. These are contained in the file "Rum". These were run on all 737 subjects.

SPSSX. The final statistical package to be used was the SPSSX statistical package (SPSSX, 1983). SPSSX was used to obtain the observed means on the 70 nutrients and other dietary components listed in the computer file "Rummage.dat" (See Appendix E for exact listing of the nutrients) broken down by sex and by density. This was accomplished using the SPSSX command files, Spsdesc.com and Spsobx,.com. The output of these runs are the files Spsdesc.out and Spsobx.out. For an exact listing of contents see Appendix E.

Appendix E: Documentation of Computer Files Used to Run the Statistics

Introduction

This appendix contains the documentation of the computer files used in determining the statistics of this project. They are in alphabetical order. The actual files are recorded on the tape "Darks".

Documentation

FILE: AOVTAFEX.OUT

NOTE:

1) File created in Minitab by reading the file DAILYSRT.COLS1.

2) Definitions for the abbreviations used in this file may be found in the file DAILYS.DAT.

3) Contains the following columns:

COLUMNS	CONTENT	FROM
C1	Monsen TAFE	Item #17 of DAILYSRT.DAT
C2	TAFOC(1)	Item #18 "
C3	TAFOC(2)	#19
C4	TAFOC(3)	#20
C5	TAFOC(4)	#21
C6	TAFOC(5)	#22
C7	TAFOA(1)	#23
C8	TAFOA(2)	#24
C9	TAFOA(3)	#25
C10	TAFOA(4)	#26
C11	TAFOA(5)	#27
C12	TACIB	#28
C13	TAVDIB	#29
C14	TACIB1	#30
C15	TAVDIB1	#31
C16	TAFE,Calc'd,GCP	#32
C17	TAFE,Actual,GCP	#33

3) Analysis of variance was performed as follows and is recorded in this file.

a) C1-C11

b) C1,C12-C15

c) C1,C16-C17

FILE: CROSS6.COM, CROSS6.OUT

NOTE:

1) SPSSX command file to determine number of subjects in each of the "new cells" created by the SAMMTH_.COM and SAMPMTH_.COM files.

2) The new cells contain the following number of subjects:

	Density 1	2	3
Sex 1	99	97	35
Sex 2	88	98	34

This information is contained in CROSS6.OUT.

FILE: DAILYMEANS.DAT

NOTE:

1) DAILYMEANS.DAT1 is a file containing the mean, median, standard deviation etc. for items 1-16 of the file DAILYSRT.DAT.

2) DAILYMEANS.DAT2 is a file containing the mean, median, standard deviation etc. for items 17-33 of the file DAILYSRT.DAT.

3) DAILYMEANS.DAT3 is a file containing the mean, median, standard deviation etc. for items 34-48 of the file DAILYSRT.DAT.

4) DAILYMEANS.DAT4 is a file containing the mean, median, standard deviation etc. for items 49-66 of the file DAILYSRT.DAT.

FILE: DATMAN.TOT, DATMAN.SRT

NOTE:

1) DATMAN.TOT was a data file created by the program Public Cols from the data file DAILYSRT.DAT so the SPSSX Manova program could be run for statistical analysis of the data. The variable names have been changed in this file from those used in DAILYSRT.DAT for more orderly interpretation of the statistical data. Variable names appear in capital letters. Old variable names appear in capital letters within parenthesis. The number immediately proceding the new variable name refers to the position the variable will occupy in the anova to be run statistically.

2) DATMAN.SRT is the same data file as DATMAN.TOT. It has been sorted by sex and density.

3) The SPSSX Manova procedure was later found to have a "bug" in it and thus the statistical program Rummage was then used. The data of DATMAN.SRT was transformed into the file RUMMAGE.DAT so that Rummage could later be used. RUMMAGE.DAT is documented later in this appendix.

FORMAT:

COLUMNS	CONTENT	FORMAT	FORMER ITEM #
1-5	ID	I5	#1 from DAILYSRT.DAT

6-7	SEX	I2	#4 from same
8-13	DENSITY (mg Fe per 1000 kcal)	F6.3	#16 same
14-17	HMCM1 - Heme Fe, calc'd, Monsen, 1 refers to position this variable will occupy in the statistical procedure (DCHF)	F4.2	#49 same
18-21	HMCO2 - Heme Fe, calc'd, OLM, 2 (HFOC)	F4.2	#53 same
22-25	HMCB3 - Heme, calc'd, Bull & Buss, 3, (CHIB)	F4.2	#58 same
26-30	HMCG4 - Heme, calc'd, GCP, 4	F5.3	#24 from FOURMLSRT.DAT
31-34	HMVDO5 - Heme, value derived (i.e. actual), OLM, 5, (AHFOA/.23)	F4.2	#57 from DAILYSRT.DAT divided by .23
35-38	HMVDB6 - Heme, value derived, Bull & Buss,6	F4.2	Same as above
39-43	HMVDG7 - Heme, value derived, GCP, 7	F5.3	#23 from FOURMLSRT.DAT
44-48	NHCM1- Nonheme, calc'd Monsen, 1, (DNONH)	F5.2	#51 from DAILYSRT.DAT
49-53	NHCO2 - Nonheme, calc'd, OLM, 2, (NONHOC)	F5.2	#54 same
54-58	NHCB3 - Nonheme, calc'd, Bull & Buss, 3, (CNHIB)	F5.2	#63 same
59-63	NHCG4 - Nonheme, calc'd, GCP, 4	F5.3	#28 from FOURMLSRT.DAT divided by .23
64-68	NHVDO5 - Nonheme, value derived, OLM, 5 (NHFOA)	F5.2	#56 from DAILYSRT.DAT
69-73	NHVDB6 - Nonheme value derived, Bull & Buss, 6, (VDNIB)	F5.2	#65 same
74-78	NHVDG7 - Nonheme, value derived, GCP, 7	F5.2	#31 from FOURMLSRT.DAT
79-82	AVHCM1 - Available heme, calc'd, Monsen, 1, (DACHF)	F4.2	#50 from DAILYSRT.DAT
83-86	AVHCO2 - Available heme, calc'd, OLM, 2 (AHFOC)	F4.2	#55 same
87-90	AVHCB3 - Available heme, calc'd, Bull & Buss, 3, (ACHIB)	F4.2	#59 same
91-95	AVHCG4 - Available heme, calc'd, GCP, 4	F5.3	#25 from FOURMLSRT.DAT
96-99	AVHVDO5 - Available heme, value derived,	F4.2	#57 from DAILYSRT.DAT

	OLM, 5, (AHFOA)		
100-103	AVHVDB6 - Available heme, value derived, Bull & Buss, 6, (AHFOA)	F4.2	#57 same
104-108	AVHVDG7 - Available heme, value derived, GCP, 7	F5.3	#30 from FOURMLSRT.DAT
109-112	ANHCM1 - Available nonheme, calc'd, Monsen,1 (DANHF)	F4.2	#52 from DAILYSRT.DAT
113-116	ANHCO12 - Available nonheme, calc'd, OLM, with EF/1, 2, (ANHFOC(1))	F4.2	#39 same
117-120	ANHCO23 - Available nonheme, calc'd, OLM, with EF/3, 3, (ANHFOC(2))	F4.2	#40 same
121-124	ANHCO34 - Available nonheme, calc'd, OLM, with EF/4, 4, (ANHFOC(3))	F4.2	#41 same
125-128	ANHCO45 - Available nonheme, calc'd, OLM, with EF/5, 5, (ANHFOC(4))	F4.2	#42 same
129-132	ANHCO56 - Available nonheme, calc'd, OLM, with EF/6, 6, (ANHFOC(5))	F4.2	#43 same
133-136	ANHCB7 - Available nonheme, calc'd, Bull & Buss, 7, (ACNHIB)	F4.2	#64 same
137-141	ANHCG8 - Available nonheme, calc'd, GCP, 8	F5.3	#28 from FOURMLSRT.DAT
142-145	ANVDO19 - Available nonheme, value derived, OLM, with EF/1, 9, (ANHFOA(1))	F4.2	#44 from DAILYSRT.DAT
146-149	ANVDO210 - Available nonheme, value derived, OLM, with EF/3, 10 (ANHFOA(2))	F4.2	#45 same
150-153	ANVDO311 - Available nonheme, value derived, OLM, with EF/4, 11, (ANHFOA(3))	F4.2	#46 same
154-157	ANVDO412 - Available nonheme, value derived, OLM, with EF/5, 12, (ANHFOA(4))	F4.2	#47 same
158-161	ANVDO513 - Available nonheme, value derived, OLM, with EF/6, 13, (ANHFOA(5))	F4.2	#48 same
162-165	ANHVDB14 - Available nonheme, value derived, Bull & Buss, 14, (AVDNIB)	F4.2	#66 same
166-170	ANHVDG15 - Available	F5.2	#32 from

	nonheme, value derived, GCP, 15		FOURMLSRT.DAT
171-174	TAFM1 - Total available Fe, Monsen, 1	F4.2	#17 from DAILYSRT.DAT
175-178	TAFC012 - Total available Fe, calc'd, OLM, with EF/1, 2, (TAFOC(1))	F4.2	#18 same
179-182	TAFC023 - Total available Fe, calc'd, OLM, with EF/3, 3, (TAFOC(2))	F4.2	#19 same
183-186	TAFC034 - Total available Fe, calc'd, OLM, with EF/4, 4, (TAFOC(3))	F4.2	#20 same
187-190	TAFC045 - Total available Fe, calc'd, OLM, with EF/5, 5, (TAFOC(4))	F4.2	#21 same
191-194	TAFC056 - Total available Fe, calc'd, OLM, with EF/6, 6, (TAFOC(5))	F4.2	#22 same
195-198	TAFCB57 - Total available Fe, calc'd, Bull & Buss, 5% fortification Fe, 7, (TACIB)	F4.2	#28 same
199-202	TAFCB18 - Total available Fe, calc'd, Bull & Buss, 1% fortification Fe, 8, (TACIB1)	F4.2	#30 same
203-206	TAFCG9 - Total available Fe, calc'd, GCP, 9,	F4.2	#32 same
207-210	TAVD0110 - Total available, value derived, OLM, with EF/1, 10, (TAFOA(1))	F4.2	#23 same
211-214	TAVD0211 - Total available, value derived, OLM, with EF/3, 11, (TAFOA(2))	F4.2	#24 same
215-218	TAVD0312 - Total available, value derived, OLM, with EF/4, 12, (TAFOA(3))	F4.2	#25 same
219-222	TAVD0413 - Total available, value derived, OLM, with EF/5, 13, (TAFOA(4))	F4.2	#26 same
223-226	TAVD0514 - Total available, value derived, OLM, with EF/6, 14, (TAFOA(5))	F4.2	#27 same
227-230	TAVDB15 - Total available, value derived, OLM, with 5% fortification iron, 15, (TAVDIB)	F4.2	#29 same

231-234	TAVDB116 - Total available, value derived, OLM, with 1% fortification iron, 16, (TAVDIB1)	F4.2	#31 same
235-238	TAFVDG17 - Total available, value derived, GCP, 17	F4.2	#33 same
239-244	HT1 - Height	F6.2	#2 same
245-250	WT2 - Weight	F6.2	#3 same
251-252	AGE3 - Age	F2.0	#5 same
253-257	KCAL4 - Kcal consumed	F5.0	#6 same
258-262	PRO5 - Protein	F5.1	#7 same
263-267	FAT6 - Fat	F5.1	#8 same
268-272	CHO7 - Carbohydrate	F5.1	#9 same
273-276	CRFIB8 - Crude Fiber	F4.1	#10 same
277-281	FE9 - Iron consumed	F5.2	#11 same
282-286	VC10 - Vit C consumed	F5.1	#12 same
287-291	GMFP11 - g MFP	F5.1	#13 same
292-295	MFPFE12 - MFP Fe	F4.2	#14 same
296-300	ACTHM13 - mg actual heme consumed	F5.2	#15 same

FILE: FOURGCP.COL,FOURMON.COL,FROTH1.COL,FROTH2.COL

NOTE:

1) These files were created from FOURMLSRT.DAT to make smaller files of the same data so that they may be used with the Minitab statistical package.
2) These files were used to generate all the X *.AOV files.
3) FOURGCP.COL contains columns 140-209 or items 24-33 of FOURMLSRT.DAT.
4) FOURMON.COL contains columns 63-104 and items 13-18 of FOURMLSRT.DAT.
5) FROTH1.COL contains columns 1-62 and items 1-12 of FOURMLSRT.DAT.
6) FROTH2.COL contains columns 105-139 and items 19-23 of FOURMLSRT.DAT.

FILE: FROTH1.AVG, FROTH1X.AVG, FROTHX.AVG, FROTH2.AVG, FROTHXX.AVG

NOTE:

1) These files were created in Minitab and contain the "described" values of Minitab (i.e mean, median, trmean, standard deviation, minimum, maximum) for the nutrients contained in each file.
2) FROTH1.AVG contains "described values" for items 3,4,6-12 of FOURMLSRT.DAT for daily totals, the breakfast meal, and lunch meals. The column contents are documented below. Columns C1-C9 describe the daily totals. Columns C10-C18 describe the breakfast meal. Columns C19-C27 describe the lunch meal.

3) FROTH1X.AVG contains "described values" for items 3,4,6-12 of FOURMLSRT.DAT for the dinner meal. The column contents are as documented below. Columns C28-C36 describe the dinner meal.
4) FROTHX.AVG contains "described values" for items 3,4,6-12 of FOURMLSRT.DAT for the "snack" meal. The column contents are as documented below. Columns C37-C45 describe the "snack" meal.
5) FROTH1.AVG, FROTH1X.AVG, FROTHX.AVG contain the following columns:

COLUMNS	CONTENT	FORMER ITEM # FOURMLSRT.DAT
C1,10,19,28,37	Height	3
C2,11,20,29,38	Weight	4
C3,12,21,30,39	Age	6
C4,13,22,31,40	Kcal consumed	7
C5,14,23,32,41	Fe consumed	8
C6,15,24,33,42	Vit C consumed	9
C7,16,25,34,43	g MFP consumed	10
C8,17,26,35,44	mg MFP Fe consumed	11
C9,18,27,36,45	mg heme Fe consumed	12

6) FROTH2.AVG contains the "described" values of Minitab for items 19-23 or columns 105-139 of FOURMLSRT.DAT for daily totals, breakfast, lunch, dinner. The column contents are as documented below. Columns C1-C5 describe the daily totals. Columns C6-C10 describe the breakfast meal. Columns C11-C15 describe the lunch meal. Columns C16-C20 describe the dinner meal.
7)FROTHXX.AVG contains the "described" values of Minitab for items 19-23 or columns 105-139 of FOURMLSRT.DAT for the snack meal. The column contents are as documented below. Columns C21-C25 describe the daily totals.
8) FROTH2.AVG, FROTHXX.AVG contain the following columns:

COLUMNS	CONTENT	ITEM # from FOURMLSRT.DAT
C1,C6,C11,C16,C21	Fe (GCP)	19
C2,C7,C12,C17,C22	Vit. C (GCP)	20
C3,C8,C13,C18,C23	g MFP (GCP)	21
C4,C9,C14,C19,C24	mg MFP Fe (GCP)	22
C5,C10,C15,C20,C25	mg actual heme Fe (GCP)	23

FILE: FROTHT.AOV, FROTHB.AOV, FROTHL.AOV, FROTHD.AOV, FROTHS.AOV
NOTE:
1) FROTHT.AOV contains the Minitab "described" values for items 8-12, 19-23 of FOURMLSRT.DAT for daily nutrient totals. This file also contains analyses of variance for C1 and C6, C2 and C7, C3 and C8, C4 and C9, C5 and C10. The columns of FROTHT.AOV are as follows:

COLUMNS	CONTENTS	ITEM # from FOURMLSRT.DAT
C1	Fe consumed	#8

C2	Vit C consumed	#9
C3	g MFP consumed	#10
C4	mg MFP Fe consumed	#11
C5	mg heme Fe consumed	#12
C6	Fe (GCP)	#19
C7	Vit C (GCP)	#20
C8	g MFP (GCP)	#21
C9	mg MFP Fe (GCP)	#22
C10	mg actual heme Fe (GCP)	#23

2) FROTHB.AOV contains the Minitab "described" values for items 8-12, 19-23 of FOURMLSRT.DAT for the breakfast meal. This file also contains analyses of variance on C1 and C6, C2 and C7, C3 and C8, C4 and C9, C5 and C10. The columns of FROTHB.AOV are the same as those documented for FROTHT.AOV.
3) FROTHL.AOV contains the Minitab "described" values for items 8-12, 19-23 of FOURMLSRT.DAT for the lunch meal. This file also contains analyses of variance on C1 and C6, C2 and C7, C3 and C8, C4 and C9, C5 and C10. The columns of FROTHL.AOV are the same as those documented for FROTHT.AOV.
4) FROTHD.AOV contains the Minitab "described" values for items 8-12, 19-23 of FOURMLSRT.DAT for the dinner meal. This file also contains analyses of variance on C1 and C6, C2 and C7, C3 and C8, C4 and C9, C5 and C10. The columns of FROTHD.AOV are the same as those documented for FROTHT.AOV.
5) FROTHS.AOV contains the Minitab "described" values for items 8-12, 19-23 of FOURMLSRT.DAT for the snack meal. This file also contains analyses of variance on C1 and C6, C2 and C7, C3 and C8, C4 and C9, C5 and C10. The columns of FROTHS.AOV are the same as those documented for FROTHT.AOV.

<u>FILE:</u> ID.FOR
<u>NOTE:</u>
1) Fortran program to create RUMMAGE.DAT from DATMAN.SRT.

<u>FILE:</u> METH6.DAT
<u>NOTE:</u>
1) This file was created by the SPSSX command file RMDATDAT.COM.
2) This file contains each "cell" of RUMMAGE.DAT. Within each cell, each method, not giving redundant values, used to determine heme iron and available iron is coded 1-6. Number 1 refers to Monsen; # 2,5 refer to OLM; #3 refer to Bull & Buss; #7,10 refer to GCP.
3) The abbreviations used in this file are defined and documented in the file RUMMAGE.DAT of this appendix.
<u>FORMAT:</u>
COLUMNS CONTENT

1-3	Subject ID number
4-5	Method code (#1-6 as described above)
6	Sex: 1 = Male, 2 = Female
7	New density: 1 = 0-5.999 mg Fe/1000 kcal, 2 = 6-8.999 mg Fe/1000 kcal, 3 = 9 mg Fe per 1000 kcal or above
8-11, Method 1 or record 1	HMCM1 (F4.2)
8-11, Method 2	HMCO2 (F4.2)
8-11, Method 3	HMCB3 (F4.2)
8-11, Method 4	HMCG4 (F4.2)
8-11, Method 5	HMVDO5 and HMVDB6 (Have same values, F4.2)
8-11, Method 6	HMVDG7 (F4.2)
12-15, Method 1	AVHCM1 (F4.2)
12-15, Method 2	AVHCO2 (F4.2)
12-15, Method 3	AVHCB3 (F4.2)
12-15, Method 4	AVHCG4 (F4.2)
12-15, Method 5	AVHVDO5 and AVHDB6 (Same values, F4.2)
12-15, Method 6	AVHVDG7 (F4.2)

FILE: METH7.DAT

NOTE:

1) This file was created by the SPSSX command file RMDATDAT.COM.

2) This file contains each "cell" of RUMMAGE.DAT. Within each cell, each method used to determine nonheme iron is coded 1-7. Number 1 refers to Monsen; # 2,5 refer to OLM; #3,6 refer to Bull & Buss, #4,7 refer to GCP.

3) The abbreviations used in this file are defined and documented in the file RUMMAGE.DAT of this appendix.

FORMAT:

COLUMNS	CONTENT
1-3	Subject ID number
4-5	Method code (#1-7 as described above)
6	Sex: 1 = Male, 2 = Female
7	New density: 1 = 0-5.999 mg Fe/1000 kcal, 2 = 6-8.999 mg Fe/1000 kcal, 3 = 9 mg Fe per 1000 kcal or above
8-12, Method 1 or record 1	NHCM1 (F5.2)
8-12, Method 2	NHCO2 (F5.2)
8-12, Method 3	NHCB3 (F5.2)
8-12, Method 4	NHCG4 (F5.2)
8-12, Method 5	NHVDO5 (F5.2)
8-12, Method 6	NHVDB6 (F5.2)
8-12, Method 7	NHVDG7 (F5.2)

FILE: METH15.DAT

NOTE:

1) This file was created by the SPSSX command file RMDATDAT.COM.

2) This file contains each "cell" of RUMMAGE.DAT. Within each cell each method used to determine available nonheme is coded 1-15. Number 1 refers to Monsen; # 2-6, 9-13 refer to OLM; #7,14 refer to Bull & Buss, #8,15 refer to GCP.

3) The abbreviations used in this file are defined in file RUMMAGE.DAT which can be found in this appendix.

4) The format of each variable is given in parenthesis.

FORMAT:

COLUMNS	CONTENT
1-3	Subject ID number
4-5	Method code (#1-15 as described above)
6	Sex: 1 = Male, 2 = Female
7	New density: 1 = 0-5.999 mg Fe/1000 kcal, 2 = 6-8.999 mg Fe/1000 kcal, 3 = 9 mg Fe per 1000 kcal or above
8-11, Method 1 or record 1	ANHCM1 (F4.2)
8-11, Method 2	ANHCO12 (F4.2)
8-11, Method 3	ANHCO23 (F4.2)
8-11, Method 4	ANHCO34 (F4.2)
8-11, Method 5	ANHCO45 (F4.2)
8-11, Method 6	ANHCO56 (F4.2)
8-11, Method 7	ANHCB7 (F4.2)
8-11, Method 8	ANHCG8 (F4.2)
8-11, Method 9	ANHVDO19 (F4.2)
8-11, Method 10	ANHVDO210 (F4.2)
8-11, Method 11	ANHVDO311 (F4.2)
8-11, Method 12	ANVDO412 (F4.2)
8-11, Method 13	ANVDO513 (F4.2)
8-11, Method 14	ANHVDB14 (F4.2)
8-11, Method 15	ANHVDG15 (F4.2)

FILE: METH17.DAT

NOTE:

1) This file was created by the SPSSX command file RMDATDAT.COM.

2) This file contains each "cell" of RUMMAGE.DAT. Within each cell each method used to determine total available iron is coded 1-17. Number 1 refers to Monsen; # 2-6, 10-14 refer to OLM; #7,8,15,16 refer to Bull & Buss, #9,17 refer to GCP.

3) The abbreviations used in this file are defined and documented in the file RUMMAGE.DAT of this appendix.

4) The format of each variable is given in parenthesis.

FORMAT:

COLUMNS	CONTENT

1-3	Subject ID number
4-5	Method code (#1-17 as described above)
6	Sex: 1 = Male, 2 = Female
7	New density: 1 = 0-5.999 mg Fe/1000 kcal, 2 = 6-8.999 mg Fe/1000 kcal, 3 = 9 mg Fe per 1000 kcal or above
8-11, Method 1 or record 1	TAFM1 (F4.2)
8-11, Method 2	TAFC012 (F4.2)
8-11, Method 3	TAFC023 (F4.2)
8-11, Method 4	TAFC034 (F4.2)
8-11, Method 5	TAFC045 (F4.2)
8-11, Method 6	TAFC056 (F4.2)
8-11, Method 7	TAFCB57 (F4.2)
8-11, Method 8	TAFCB18 (F4.2)
8-11, Method 9	TAFCG9 (F4.2)
8-11, Method 10	TAVD0110 (F4.2)
8-11, Method 11	TAVD0211 (F4.2)
8-11, Method 12	TAVD0312 (F4.2)
8-11, Method 13	TAVD0413 (F4.2)
8-11, Method 14	TAVD0514 (F4.2)
8-11, Method 15	TAVD0514 (F4.2)
8-11, Method 16	TAVDB116 (F4.2)
8-11, Method 17	TAFVDG17 (F4.2)

<u>FILE:</u> METH151.DAT, METH152.DAT, METH153.DAT, METH154.DAT, METH155.DAT, METH171.DAT, METH172.DAT, METH173.DAT, METH174.DAT, METH175.DAT, METH61.DAT, METH62.DAT, METH63.DAT, METH64.DAT, METH65.DAT, METH71.DAT, METH72.DAT, METH73.DAT, METH74.DAT, METH75.DAT, SAMMTH15.COM, SAMMTH15.OUT, SAMMTH17.COM, SAMMTH17.OUT, SAMPMTH6.COM, SAMPMTH6.OUT, SAMPMTH7.COM, SAMPMTH7.OUT.

<u>NOTE:</u>

1) METH151.DAT through METH155.DAT are data files created by the SPSSX command file SAMMTH15.COM. The output of running the command file SAMMTH15.COM is SAMMTH15.OUT. The contents of these files are the same as those of METH15.DAT. However these files have "cells" which contain only 99 subjects or less. Rummage can only be run on cells with 99 or fewer subjects.

2) METH171.DAT through METH175.DAT are data files created by the SPSSX command file SAMMTH17.COM. The output of running the command file SAMMTH17.COM is SAMMTH17.OUT. The contents of these files are the same as those of METH17.DAT. However these files have "cells" which contain only 99 subjects or less. Rummage can only be run on cells with 99 or fewer subjects.

3) METH61.DAT through METH65.DAT are data files created by the SPSSX command file SAMPMTH6.COM. The output of running the command file SAMPMTH6.COM is SAMPMTH6.OUT. The contents of these files are the same as those of METH6.DAT. However these files have "cells" which

contain only 99 subjects or less. Rummage can only be run on cells with 99 or fewer subjects.
3) METH51.DAT through METH55.DAT are data files created by the SPSSX command file SAMPMTH5.COM. The output of running the command file SAMPMTH5.COM is SAMPMTH5.OUT. The contents of these files are the same as those of METH5.DAT. However these files have "cells" which contain only 99 subjects or less. Rummage can only be run on cells with 99 or fewer subjects. Each "cell" is designated by the second number in the name. For example METH51.DAT contains the same data as METH5.DAT (see documentation under that file heading) but is for the 1,1 cell (i.e new density = 1 and sex = 1 - see documentation of "cells" under the file heading RUMMAGE.DAT).

FILE: METH6.DT, METH7.DT, METH17.DT, METH15.DT
NOTE:
1) METH6.DT is the combination of METH61.DAT, METH62.DAT, METH63.DAT, METH64.DAT, METH65.DAT.
2) METH7.DT is the combination of METH71.DAT, METH72.DAT, METH73.DAT, METH74.DAT, METH75.DAT.
3) METH17.DT is the combination of METH171.DAT, METH172.DAT, METH173.DAT, METH174.DAT, METH175.DAT.
4) METH15.DT is the combination of METH151.DAT, METH152.DAT, METH153.DAT, METH154.DAT, METH155.DAT.

FILE: METH15.DT2, METH17.DT2, METH6.DT2, METH7.DT2, NEWID15.FOR, NEWID17.FOR, NEWID6.FOR, NEWID7.FOR
NOTE:
1) METH15.DT2 is the same as METH15.DT although the subjects have sequentially numbered ID numbers in this version. This file was created by the fortran program NEWID15.FOR.
2) METH17.DT2 is the same as METH17.DT although the subjects have sequentially numbered ID numbers in this version. This file was created by the fortran program NEWID17.FOR.
3) METH7.DT2 is the same as METH7.DT although the subjects have sequentially numbered ID numbers in this version. This file was created by the fortran program NEWID7.FOR.
4) METH6.DT2 is the same as METH6.DT although the subjects have sequentially numbered ID numbers in this version. This file was created by the fortran program NEWID6.FOR.

FILE: RMDATDAT.COM, RUMDD.OUT
NOTE:
1) RMDATDAT.COM is a SPSSX command file to sort RUMMAGE.DAT into the files METH17.DAT, METH6.DAT,

METH7.DAT and METH15.DAT. These were the files on which the Rummage statistical program was ultimately run.
2) RUMDD.OUT is the output file of running the SPSSX command file, RMDATDAT.COM.

FILE: RUMMAGE.DAT

NOTE:

1) RUMMAGE.DAT was a data file created by the program ID.FOR from the data file DATMAN.SRT so the Rummage statistical package could be used to analyze the data. The variable names have been changed in this file, as was done DATMAN.TOT and DATMAN.SRT, from those used in DAILYSRT.DAT for more orderly intrepretation of the statistical data. Variable names appear in capital letters. Old variable names appear in capital letters within parenthesis. The number immediately proceding the new variable name refers to the position the variable will occupy in the anova to be run statistically.
2) RUMMAGE.DAT was sorted into six "cells" by sex, and by density. These cells are as follows and contain the following number of subjects:
   a) Cell #1,1 - Equals new density 1, sex 1, contains 165 subjects
   b) Cell #2,1 - New density 2, sex 1, contains 155 subjects
   c) Cell #3,1 - New density 3, sex 1, contains 35 subjects
   d) Cell #1,2 - New density 1, sex 2, contains 176 subjects
   e) Cell #2,2 - New density 2, sex 2, contains 172 subjects
   f) Cell #3,2 - New density 3, sex 2, contains 34 subjects
3) A new column of data was also added to this file which was previously not in DATMAN.SRT. This new column of data is "new density" and was created by recoding the "old iron density" (i.e mg Fe per 1000 kcal consumed) into the following categories:
   a) 0-5.999 mg Fe/1000 kcal consumed = 1
   b) 6-8.999 mg Fe/1000 kcal consumed = 2
   c) 9 or greater mg Fe/1000 kcal consumed = 3

FORMAT:

COLUMNS	CONTENT	FORMAT	FORMER ITEM #
1-4	SUBJECT NUMBER	I4	New
5	NEW DENSITY	I1	New
6-7	SEX	I2	#4 from DAILYSRT.DAT
8-13	DENSITY (mg Fe per 1000 kcal, this is "old density")	F6.3	#16 same
14-17	HMCM1 - Heme Fe, calc'd, Monsen, 1	F4.2	#49 same

	refers to position this variable will occupy in the statistical procedure (DCHF)		
18-21	HMCO2 - Heme Fe, calc'd, OLM, 2 (HFOC)	F4.2	#53 same
22-25	HMCB3 - Heme, calc'd, Bull & Buss, 3, (CHIB)	F4.2	#58 same
26-30	HMCG4 - Heme, calc'd, GCP, 4	F5.3	#24 from FOURMLSRT.DAT
31-34	HMVDO5 - Heme, value derived (i.e. actual), OLM, 5, (AHFOA/.23)	F4.2	#57 from DAILYSRT.DAT divided by .23
35-38	HMVDB6 - Heme, value derived, Bull & Buss,6	F4.2	Same as above
39-43	HMVDG7 - Heme, value derived, GCP, 7	F5.3	#23 from FOURMLSRT.DAT
44-48	NHCM1- Nonheme, calc'd Monsen, 1, (DNONH)	F5.2	#51 from DAILYSRT.DAT
49-53	NHCO2 - Nonheme, calc'd, OLM, 2, (NONHOC)	F5.2	#54 same
54-58	NHCB3 - Nonheme, calc'd, Bull & Buss, 3, (CNHIB)	F5.2	#63 same
59-63	NHCG4 - Nonheme, calc'd, GCP, 4	F5.3	#28 from FOURMLSRT.DAT divided by .23
64-68	NHVDO5 - Nonheme, value derived, OLM, 5 (NHFOA)	F5.2	#56 from DAILYSRT.DAT
69-73	NHVDB6 - Nonheme value derived, Bull & Buss, 6, (VDNIB)	F5.2	#65 same
74-78	NHVDG7 - Nonheme, value derived, GCP, 7	F5.2	#31 from FOURMLSRT.DAT
79-82	AVHCM1 - Available heme, calc'd, Monsen, 1, (DACHF)	F4.2	#50 from DAILYSRT.DAT
83-86	AVHCO2 - Available heme, calc'd, OLM, 2 (AHFOC)	F4.2	#55 same
87-90	AVHCB3 - Available heme, calc'd, Bull & Buss, 3, (ACHIB)	F4.2	#59 same
91-95	AVHCG4 - Available heme, calc'd, GCP, 4	F5.3	#25 from FOURMLSRT.DAT
96-99	AVHVDO5 - Available heme, value derived, OLM, 5, (AHFOA)	F4.2	#57 from DAILYSRT.DAT
100-103	AVHVDB6 - Available heme, value derived, Bull & Buss, 6, (AHFOA)	F4.2	#57 same
104-108	AVHVDG7 - Available	F5.3	#30 from

	heme, value derived, GCP, 7		FOURMLSRT.DAT
109-112	ANHCM1 - Available nonheme, calc'd, Monsen, 1 (DANHF)	F4.2	#52 from DAILYSRT.DAT
113-116	ANHCO12 - Available nonheme, calc'd, OLM, with EF/1, 2, (ANHFOC(1))	F4.2	#39 same
117-120	ANHCO23 - Available nonheme, calc'd, OLM, with EF/3, 3, (ANHFOC(2))	F4.2	#40 same
121-124	ANHCO34 - Available nonheme, calc'd, OLM, with EF/4, 4, (ANHFOC(3))	F4.2	#41 same
125-128	ANHCO45 - Available nonheme, calc'd, OLM, with EF/5, 5, (ANHFOC(4))	F4.2	#42 same
129-132	ANHCO56 - Available nonheme, calc'd, OLM, with EF/6, 6, (ANHFOC(5))	F4.2	#43 same
133-136	ANHCB7 - Available nonheme, calc'd, Bull & Buss, 7, (ACNHIB)	F4.2	#64 same
137-141	ANHCG8 - Available nonheme, calc'd, GCP, 8	F5.3	#28 from FOURMLSRT.DAT
142-145	ANVDO19 - Available nonheme, value derived, OLM, with EF/1, 9, (ANHFOA(1))	F4.2	#44 from DAILYSRT.DAT
146-149	ANVDO210 - Available nonheme, value derived, OLM, with EF/3, 10 (ANHFOA(2))	F4.2	#45 same
150-153	ANVDO311 - Available nonheme, value derived, OLM, with EF/4, 11, (ANHFOA(3))	F4.2	#46 same
154-157	ANVDO412 - Available nonheme, value derived, OLM, with EF/5, 12, (ANHFOA(4))	F4.2	#47 same
158-161	ANVDO513 - Available nonheme, value derived, OLM, with EF/6, 13, (ANHFOA(5))	F4.2	#48 same
162-165	ANHVDB14 - Available nonheme, value derived, Bull & Buss, 14, (AVDNIB)	F4.2	#66 same
166-170	ANHVDG15 - Available nonheme, value derived, GCP, 15	F5.2	#32 from FOURMLSRT.DAT
171-174	TAFM1 - Total available Fe, Monsen, 1	F4.2	#17 from DAILYSRT.DAT
175-178	TAFCO12 - Total avail-	F4.2	#18 same

	able Fe, calc'd, OLM, with EF/1, 2, (TAFOC(1))		
179-182	TAFC023 - Total available Fe, calc'd, OLM, with EF/3, 3, (TAFOC(2))	F4.2	#19 same
183-186	TAFC034 - Total available Fe, calc'd, OLM, with EF/4, 4, (TAFOC(3))	F4.2	#20 same
187-190	TAFC045 - Total available Fe, calc'd, OLM, with EF/5, 5, (TAFOC(4))	F4.2	#21 same
191-194	TAFC056 - Total available Fe, calc'd, OLM, with EF/6, 6, (TAFOC(5))	F4.2	#22 same
195-198	TAFCB57 - Total available Fe, calc'd, Bull & Buss, 5% fortification Fe, 7, (TACIB)	F4.2	#28 same
199-202	TAFCB18 - Total available Fe, calc'd, Bull & Buss, 1% fortification Fe, 8, (TACIB1)	F4.2	#30 same
203-206	TAFCG9 - Total available Fe, calc'd, GCP, 9,	F4.2	#32 same
207-210	TAVD0110 - Total available, value derived, OLM, with EF/1, 10, (TAFOA(1))	F4.2	#23 same
211-214	TAVD0211 - Total available, value derived, OLM, with EF/3, 11, (TAFOA(2))	F4.2	#24 same
215-218	TAVD0312 - Total available, value derived, OLM, with EF/4, 12, (TAFOA(3))	F4.2	#25 same
219-222	TAVD0413 - Total available, value derived, OLM, with EF/5, 13, (TAFOA(4))	F4.2	#26 same
223-226	TAVD0514 - Total available, value derived, OLM, with EF/6, 14, (TAFOA(5))	F4.2	#27 same
227-230	TAVDB15 - Total available, value derived, OLM, with 5% fortification iron, 15, (TAVDIB)	F4.2	#29 same
231-234	TAVDB116 - Total available, value derived, OLM, with 1% fortification iron, 16, (TAVDIB1)	F4.2	#31 same
235-238	TAFVDG17 - Total avail-	F4.2	#33 same

	able, value derived, GCP, 17		
239-244	HT1 - Height	F6.2	#2 same
245-250	WT2 - Weight	F6.2	#3 same
251-252	AGE3 - Age	F2.0	#5 same
253-257	KCAL4 - Kcal consumed	F5.0	#6 same
258-262	PRO5 - Protein	F5.1	#7 same
263-267	FAT6 - Fat	F5.1	#8 same
268-272	CHO7 - Carbohydrate	F5.1	#9 same
273-276	CRFIB8 - Crude Fiber	F4.1	#10 same
277-281	FE9 - Iron consumed	F5.2	#11 same
282-286	VC10 - Vit C consumed	F5.1	#12 same
287-291	GMFP11 - g MFP	F5.1	#13 same
292-295	MFPFE12 - MFP Fe	F4.2	#14 same
296-300	ACTHM13 - mg actual heme consumed	F5.2	#15 same

FILE: RUMMTH15.COM, RUMMTH15.OUT, RUMMTH17.COM, RUMMTH17.OUT, RUMMTH6.COM, RUMMTH6.OUT

NOTE:

1) RUMMTH15.COM is a Rummage command file run on the data set METH15.DT2 to perform an analysis of variance procedure for available nonheme iron. The output of this procedure is stored in RUMMTH15.OUT.
2) RUMMTH17.COM is a Rummage command file run on the data set METH17.DT2 to perform an analysis of variance procedure for available nonheme iron. The output of this procedure is stored in RUMMTH17.OUT.
3) RUMMTH6.COM is a Rummage command file run on the data set METH6.DT2 to perform an analysis of variance procedure for available nonheme iron. The output of this procedure is stored in RUMMTH6.OUT.
4) RUMMTH7.COM is a Rummage command file run on the data set METH7.DT2 to perform an analysis of variance procedure for available nonheme iron. The output of this procedure is stored in RUMMTH7.OUT.

FILE: SIXML.COL1, SIXML.COL2

NOTE:

1) These files were created from SIXMLSRT.DAT to create smaller files so that Minitab may be run on them.
2) SIXMLCOL1 contains columns 1-41 or items 1-9 of SIXMLSRT.DAT which are documented under that file heading.
3) SIXML.COL2 contains columns 42-110 or items 10-19 of SIXMLSRT.DAT which are documented under that file heading.

FILE: SIXML1S.AVG, SIXML2S.AVG,SIXML3S.AVG

NOTE:

1) These are files created by reading in the values of the three snacks consumed for the day from SIXML.COL1 and SIXML.COL2 into Minitab. SIXML1S.AVG contains the "described" values from Minitab on the nutrients consumed in the first snack. SIXML2S.AVG contains the "described" values from Minitab on the nutrients consumed in the second snack. SIXML3S.AVG contains the "described" values from Minitab on the nutrients consumed in the third snack.

2) The columns of SIXML1S.AVG, SIXML2S.AVG, SIXML3S.AVG are as follows:

COLUMN	CONTAINS	FORMER ITEM NO. FROM SIXMLSRT.DAT
C1	Height	#3
C2	Weight	#4
C3	Age	#6
C4	Kcal consumed	#7
C5	Iron consumed	#8
C6	Vit C consumed	#9
C7	g MFP consumed	#10
C8	mg MFP Fe consumed	#11
C9	mg Heme consumed	#12
C10	Calc'd heme (Monsen)	#13
C11	Available calc'd heme (Monsen)	#14
C12	EF (Monsen)	#15
C13	Nonheme iron (Monsen)	#16
C14	Available nonheme Fe (Monsen)	#17
C15	Total available Fe (Monsen)	#18
C16	mg Fe/1000 kcal	#19

3) The columns are the same for each file except that SIXML1S.DAT gives data for the first snack, SIXML2S.DAT for the second snack, and SIXML3S.DAT gives data for the third snack of the six average "meals" consumed.

FILE: SPSDESC.COM, SPSDEC.OUT

NOTE:

1) SPSDESC.COM is a SPSSX command file to obtain the "descriptive" values on height, weight, age, kcal, protein, fat, carbohydrate, crude fiber, total iron, vitamin C; grams meat, fish, poultry; mg meat, fish, poultry iron; and mg actual heme iron consumed. Theses values are found in the file SPSDESC.OUT.

FILE: SPSOBX.COM, SPSOBX.OUT

NOTE:

1) SPSOBX.COM is a SPSSX command file to obtain the observed means of total available iron, available heme

iron, heme iron, nonheme iron, and available nonheme iron.
2) SPSOBX.OUT is the output from running SPSOBX.COM.

FILE: SPSORT.CMD, SPSMAN.COM
NOTE:
1) SPSORT.CMD was a SPSSX command file to sort DATMAN.TOT by sex, density, and ID. This was run to see how the "cells" would look.
2) SPSMAN.COM was the SPSSX command file to run the Manova procedure of DATMAN.TOT which ultimately did not work.

FILE: XACHM.AOV, XANH.AOV, XCHM.AOV, XCHM2.AOV, XEF.AOV, XNHM.AOV, XXTAFE.AOV
NOTE:
1) XACHM.AOV is a file created in Minitab by reading in items #14,25,30 of the file FOURMLSRT.DAT to compare by analysis of variance the available heme values for breakfast, lunch, dinner, snacks, and totals, for the day, generated by the Monsen method to those generated by the General Consumption Pattern. The snacks (i.e 3 snacks) consumed and analyzed by the Monsen method were combined into 1 snack for this analysis so that four "meals" of Monsen could be compared with the four meals generated by the General Consumption Pattern. This file also contains the "described" values of Minitab (i.e. mean, standard deviation etc.) on each variable. The columns are as follows:

COLUMN	CONTENT	MEAL
C1	Available calc'd heme (Monsen)	Total
C2	Available calc'd heme (GCP)	Total
C3	Available actual heme	Total
C4	Available calc'd heme (Monsen)	Breakfast
C5	Available calc'd heme (GCP)	Breakfast
C6	Available actual heme	Breakfast
C7	Available calc'd heme (Monsen)	Lunch
C8	Available calc'd heme (GCP)	Lunch
C9	Available actual heme	Lunch
C10	Available calc'd heme (Monsen)	Dinner
C11	Available calc'd heme (GCP)	Dinner
C12	Available actual heme	Dinner

C13	Available calc'd heme (Monsen)	Snack
C14	Available calc'd heme (GCP)	Snack
C15	Available actual heme	Snack

2) XANH.AOV is a file created in Minitab by reading in items #17,28,32 of the file FOURMLSRT.DAT to compare by analysis of variance the available nonheme values for breakfast, lunch, dinner, snacks, and totals for the day generated by the Monsen method to those generated by the General Consumption Pattern. The snacks (i.e 3 snacks) consumed and analyzed by the Monsen method were combined into 1 snack for this analysis so that four "meals" of Monsen could be compared with the four meals generated by the General Consumption Pattern. This file also contains the "described" values of Minitab (i.e. mean, standard deviation etc.) on each variable. The columns are as follows:

COLUMN	CONTENT	MEAL
C1	Available nonheme Fe (Monsen)	Total
C2	Available nonheme Fe (GCP)	Total
C3	Available actual nonheme Fe (GCP)	Total
C4	Available nonheme Fe (Monsen)	Breakfast
C5	Available nonheme Fe (GCP)	Breakfast
C6	Available actual nonheme Fe (GCP)	Breakfast
C7	Available nonheme Fe (Monsen)	Lunch
C8	Available nonheme Fe (GCP)	Lunch
C9	Available actual nonheme Fe (GCP)	Lunch
C10	Available nonheme Fe (Monsen)	Dinner
C11	Available nonheme Fe (GCP)	Dinner
C12	Available actual nonheme Fe (GCP)	Dinner
C13	Available nonheme Fe (Monsen)	Snack
C14	Available nonheme Fe (GCP)	Snack
C15	Available actual nonheme Fe (GCP)	Snack

3) XCHM.AOV is a file created in Minitab by reading in items #13,24,30 of the file FOURMLSRT.DAT to compare

by analysis of variance the heme values for breakfast, lunch, dinner, and totals for the day generated by the Monsen method to those generated by the General Consumption Pattern. Available heme iron was divided by 0.23 to obtain actual heme iron generated by the GCP. The snack meal was analyzed in the file XCHM2.AOV. The snacks (i.e 3 snacks) consumed and analyzed by the Monsen method were combined into 1 snack for this analysis so that four "meals" of Monsen could be compared with the four meals generated by the General Consumption Pattern. This file also contains the "described" values of Minitab (i.e. mean, standard deviation etc.) on each variable. The columns are as follows:

COLUMN	CONTENT	MEAL
C1	Calc'd heme Fe (Monsen)	Total
C2	Calc'd heme Fe (GCP)	Total
C3	Available heme Fe (GCP) divided by 0.23	Total
C4	Calc'd heme Fe (Monsen)	Breakfast
C5	Calc'd heme Fe (GCP)	Breakfast
C6	Available heme Fe (GCP) divided by 0.23	Breakfast
C7	Calc'd heme Fe (Monsen)	Lunch
C8	Calc'd heme Fe (GCP)	Lunch
C9	Available heme Fe (GCP) divided by 0.23	Lunch
C10	Calc'd heme Fe (Monsen)	Dinner
C11	Calc'd heme Fe (GCP)	Dinner
C12	Available heme Fe (GCP) divided by 0.23	Dinner
C13	Calc'd heme Fe (Monsen)	Snack
C14	Calc'd heme Fe (GCP)	Snack
C15	Available heme Fe (GCP) divided by 0.23	Snack

4) XNHM.AOV is a file created in Minitab by reading in items #16,27,31 of the file FOURMLSRT.DAT to compare by analysis of variance the nonheme iron values for breakfast, lunch, dinner, snacks, and totals for the day generated by the Monsen method to those generated by the General Consumption Pattern. The snacks (i.e 3 snacks) consumed and analyzed by the Monsen method were combined into 1 snack for this analysis so that

four "meals" of Monsen could be compared with the four meals generated by the General Consumption Pattern. This file also contains the "described" values of Minitab (i.e. mean, standard deviation etc.) on each variable. The columns are as follows:

COLUMN	CONTENT	MEAL
C1	Nonheme Fe (Monsen)	Total
C2	Nonheme Fe, calculated, (GCP)	Total
C3	Nonheme Fe, actual, (GCP)	Total
C4	Nonheme Fe (Monsen)	Breakfast
C5	Nonheme Fe, calculated, (GCP)	Breakfast
C6	Nonheme Fe, actual, (GCP)	Breakfast
C7	Nonheme Fe (Monsen)	Lunch
C8	Nonheme Fe, calculated, (GCP)	Lunch
C9	Nonheme Fe, actual, (GCP)	Lunch
C10	Nonheme Fe (Monsen)	Dinner
C11	Nonheme Fe, calculated, (GCP)	Dinner
C12	Nonheme Fe, actual, (GCP)	Dinner
C13	Nonheme Fe (Monsen)	Snack
C14	Nonheme Fe, calculated, (GCP)	Snack
C15	Nonheme Fe, actual, (GCP)	Snack

5) XEF.AOV is a file created in Minitab by reading in items #15,26 of the file FOURMLSRT.DAT to compare by analysis of variance the enhancement factor values for breakfast, lunch, dinner, snacks, and totals for the day generated by the Monsen method to those generated by the General Consumption Pattern. The snacks (i.e 3 snacks) consumed and analyzed by the Monsen method were combined into 1 snack for this analysis so that four "meals" of Monsen could be compared with the four meals generated by the General Consumption Pattern. This file also contains the "described" values of Minitab (i.e. mean, standard deviation etc.) on each variable. The columns are as follows:

COLUMN	CONTENT	MEAL
C1	Enhancement factor (Monsen)	Total
C2	Enhancement factor (GCP)	Total
C3	Enhancement factor (Monsen)	Breakfast
C4	Enhancement factor (GCP)	Breakfast

C5	Enhancement factor (Monsen)	Lunch
C6	Enhancement factor (GCP)	Lunch
C7	Enhancement factor (Monsen)	Dinner
C8	Enhancement factor (GCP)	Dinner
C9	Enhancement factor (Monsen)	Snack
C10	Enhancement factor (GCP)	Snack

6) XXTAF.AOV is a file created in Minitab by reading in items #18,29,33 of the file FOURMLSRT.DAT to compare by analysis of variance the total available iron values for breakfast, lunch, dinner, snacks, and totals for the day generated by the Monsen method to those generated by the General Consumption Pattern. The snacks (i.e 3 snacks) consumed and analyzed by the Monsen method were combined into 1 snack for this analysis so that four "meals" of Monsen could be compared with the four meals generated by the General Consumption Pattern. This file also contains the "described" values of Minitab (i.e. mean, standard deviation etc.) on each variable. The columns are as follows:

COLUMN	CONTENT	MEAL
C1	Total available Fe (Monsen)	Total
C2	Total available Fe (calc'd, GCP)	Total
C3	Total available Fe (actual, GCP)	Total
C4	Total available Fe (Monsen)	Breakfast
C5	Total available Fe (calc'd, GCP)	Breakfast
C6	Total available Fe (actual, GCP)	Breakfast
C7	Total available Fe (Monsen)	Lunch
C8	Total available Fe (calc'd, GCP)	Lunch
C9	Total available Fe (actual, GCP)	Lunch
C10	Total available Fe (Monsen)	Dinner
C11	Total available Fe (calc'd, GCP)	Dinner
C12	Total available Fe (actual, GCP)	Dinner
C13	Total available Fe (Monsen)	Snack