COMPARISON OF METHODOLOGIES TO ESTIMATE DIETARY FATTY ACID INTAKE

BY

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ABSTRACT

A modified three-day food record was developed to assess intake of fat and fatty acids. Two food records were obtained from each of six volunteer subjects for a total of 12 diet records. The subjects collected duplicates of the foods eaten during the time the food records were kept. The duplicate meals were chemically analyzed for total fat and for the following fatty acids: palmitic acid (16:0), stearic acid (18:0), oleic acid (18:1), linoleic acid (18:2) and linolenic acid (18:3). The diet records were evaluated in two ways: manually, using USDA Handbook No. 8 (1963) and revised supplements together with information from manufacturers; and with a computer program, using the Canadian Nutrient File without modification. The results of the two methods of calculation were compared with the laboratory analysis. The coefficients of determination for total fat and all fatty acids except 18:2 were indicative of good agreement between both methods of calculation and the laboratory analysis. The manual calculation of total fat and of all fatty acids except 18:2 provided results that were less variable than the database calculation. Linoleic acid was poorly estimated by both methods of calculation.

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REVIEW OF LITERATURE

INTRODUCTION

Current interest in the effects of specific fatty acids on cardiovascular disease, particularly on serum cholesterol, has resulted in a number of studies correlating diet and blood lipids. Diet is the main variable in the studies, but the methods of obtaining and evaluating dietary information differ. Experimental protocol has included a number of different methods which quantitate dietary fatty acid intake. These differences are illustrated by several recent research studies.

Increasing use of fats with high levels of polyunsaturated fatty acids by the food industry has resulted in a greater interest in the quantitation of these fatty acids. Health care professionals are interested in determining the levels of these fatty acids when consumed by individuals as part of their usual diets. The omega-3 fatty acids, alpha-linolenic acid (18:3), eicosapentaenioc acid (20:5) and docosahexaenoic acid (22:6), have lately come under scrutiny. The main food sources of 20:5 and 22:6 are fish oils. Canola oil, the low erucic acid rapeseed oil which has gained a large share of the Canadian market, contains a substantial amount of 18:3.

In studies which correlate fat or fatty acids in the diets of free-living individuals with other variables, the researcher needs to make a number of decisions regarding the methods necessary to obtain the required nutrient information. The first decision to be made is what foods to include in evaluating dietary fat intake. The two main options are assessment of the total diet or assessment limited to only the experimental fats. If the rest of the diet is not expected to change apart from the addition of specific fats, use of the experimental fats only could be acceptable. However, if the researcher suspects that the fats normally used vary, then total dietary fat needs to be taken into consideration.

The next decision is the method of obtaining the dietary information necessary to determine the amount of fat or fat-containing foods in the diet. A number of options are available which include the collection of duplicates of the subjects' meals for chemical analysis; a diet recall, which requires subjects to remember what they have eaten in the past 24-48 hours; and the diet record, which requires subjects to keep a weighed or estimated record of their food intake over a certain period of time.

The third decision to be made is the period of time for which diet information will be collected. Because recall is dependant on memory, this method is limited to 24-48 hours, particularly if accurate detail is required. The weighed or estimated record can encompass a much longer span of time and is therefore more useful for determining habitual intake. The immediacy of the record-keeping also ensures greater accuracy, which could be of particular importance in determining the intake of fatty acid.

Several investigators have asked subjects to consume their usual diet but to substitute experimental fats for fats usually consumed. Weighed diets were used by Ferro-Luzzi et al. (1984), who wished to identify the effects of changes in fat composition of the typical Mediterranean diet which consists of cereals, vegetables and olive oil. The subjects were 48 healthy middle-aged men and women from a rural area in southern Italy. Trained professionals visited individual homes and monitored the diets. The usual food intake of each individual was weighed for seven consecutive days and constituted the baseline data. The experimental diet replaced usual fats with butter, dairy cream, cheese and small amounts of meat. During the experimental period of 12 weeks, diets were weighed every third day. The diet information was processed using an updated and supplemented database from the Italian Ministry of Agriculture and the National Institute of Nutrition. The diets were monitored for oleic acid (18:1), linoleic acid (18:2), cholesterol and the P:S ratio.

Sirtori et al. (1986), studied the diets of 23 free-living hyperlipidemic subjects who also consumed the Mediterranean diet. Baseline diet data was obtained using a 48-hour recall. Olive and corn oil were supplied to the subjects and the subjects were instructed to substitute each of these fats for all dietary fats usually consumed. They were also instructed to reduce their overall intake of fat. Food frequency questionnaires were completed by the subjects during the experimental period. The fatty acid composition of the olive and corn oils was used to evaluate the effect of diet on blood lipids and platelet function. Total composition of the dietary fat other than the oils was not considered.

The effects of 18:2 and 18:3 on platelet function and composition were studied by Renaud et al. (1986) during a three-year study involving a group of farmers in a region of northeastern France. The subjects were supplied with sunflower and/or canola oils and margarines which were high in 18:2 and 18:3, respectively. These fats were substituted for the saturated fats normally used by the subjects. Dietary information was obtained using a 24-hour recall and one-day weighed food record. Evaluation was done using a food table adapted from USDA Handbook No.8 (1963), McCance and Widdowson's Table of Food Composition (1978) and chemically analyzed data for meats and fats of the region. A comparison with values reported in an earlier study by the researchers in the south of France led them to conclude that platelet behaviour is dependant on the intake of particular fatty acids and is not primarily due to genetic factors. This observation suggests that accurate estimates of dietary fatty acid intake are an important aspect of dietary surveillance.

In studies discussed previously, the change in fatty acid intake was assessed by comparing the usual diet with a diet in which the fats were controlled. Commonly used fats were provided to subjects for substitution in the study conducted by Ferro-Luzzi et al. (1984). The fatty acid composition was determined on the basis of a weighed diet. The fatty acids were calculated using a database analysis of weighed food records. Sirtori et al. (1986), also supplied the fat sources for substitution in the diet. Only the experimental fats were chemically analyzed for fatty acid composition. Consumption of the substituted fats was monitored by Sirtori et al. (1986) using a food frequency questionnaire. Total dietary fat was not monitored. Renaud et al. (1986) supplied subjects with specially formulated fats and assessed intake of fatty acids using a combined recall and weighed record of the total diet. Evaluation was done using published food tables and chemical analysis data.

The conclusions by Ferro-Luzzi et al. (1984), Sirtori et al. (1986) and Renaud et al. (1986) depended on accurate information about dietary fat intake. It is apparent from these studies, however, that there is no agreement as to how diet information is best obtained. In the study conducted by Sirtori et al. (1986) only the experimental fats were taken into consideration and the rest of the diet disregarded. In the other two studies total dietary fat was estimated using food records, but the fatty acid intake was calculated using two different methods. Ferro-Luzzi et al.(1984) used a computer database only. Renaud et al. (1986) used a combination of chemical analysis of some of the foods in the diets and manual calculation using food composition tables.

The source of the fatty acid composition data used to calculate intake may have an effect on the reported intakes. The studies by Ferro-Luzzi et al. (1984), Sirtori et al. (1986) and Renaud et al. (1986) each used different sources of data to assess fatty acid intake. These sources are not necessarily equally accurate. A comparison of chemically analyzed diets, calculation using computer databases and calculation from food tables, should indicate whether there are differences in sources used to evaluate dietary fatty acids.

COLLECTION OF DIET INFORMATION

When determining the fatty acid intake of a free-living group of subjects consuming self-selected diets the total diet should be assessed rather than only the experimental fats. The variety of foods and fat sources available in North America makes it difficult to determine what individuals might be consuming at any given time. Many consumers also change their eating patterns in response to price fluctuations and to the introduction of new products. The variety of foods used by different ethnic groups also makes it difficult to predict consumption patterns unless the subjects are from a clearly defined group eating identifiable foods.

As has been noted, a number of different methods of obtaining diet information have been used: chemical analysis of meal duplicates; dietary recall; and a weighed or estimated food record. These methods vary in the accuracy of the nutrient information provided, and their use needs to be assessed according to the accuracy required or even possible.

The most accurate method of obtaining nutrient intake data is by chemically analyzing a duplicate of the meals consumed by the subject. However, this method is costly and since the availability of research funds is often limited, it usually is not a realistic option, especially for large groups of subjects. Chemical analysis of foods is most efficiently used in setting up food composition tables which are in turn used to analyze diet record information. Murphy et al. (1973) also pointed out that chemical analysis may not be suitable for determining long-term intake, since duplicate meal samples, normally taken for a one-day period, reflect only specific foods eaten on a particular day. Chemical analysis of the food consumed in one day would therefore not necessarily be typical of long-term food intake.

The dietary recall method is limited to a period of intake of 24 or 48 hours, or to the use of food frequency information, which is a type of recall used to ascertain food use. The recall method is probably the most inaccurate since it involves the fallible human memory. In addition, there is little descriptive information about individual foods using this method and it would not be the method of choice where fatty acid calculation is of primary concern (Liu et al., 1977). Its use should be limited to an evaluation of trends or patterns of food consumption. The main strength of the recall method lies in the fact that subjects do not change their pattern of food consumption.

The food record is a method in which the subject records some measure or estimate of the food eaten over a specified period of time. It provides the subject with more opportunity to describe the foods consumed. This method is more suitable for smaller clinical trials or for monitoring individual intakes. A further decision must be made between a weighed record and an estimated record. A daily weighed record can be more accurate than an estimated record for the calculation of nutrients. However, there are some disadvantages to this method for collecting diet information. First of all, providing scales or balances for all the subjects can be costly. Secondly, one must either have constant supervision of the subjects or provide sufficient motivation to ensure that the records include all foods consumed and reflect the subjects' habitual patterns of food intake. The burden of recording intake is increased by the need to weigh the foods and may lead to "forgetting" to weigh some foods or refusing foods that would otherwise be consumed except for the bother of weighing them. The estimated record attempts to minimize these difficulties by providing an easier method for subjects to report food intake while sacrificing some degree of accuracy.

When estimating food intake, accuracy of estimation of food consumed is an important factor in the accuracy of nutrient analysis. Peterson et al. (1986) compared calculated estimates by trained observers with analyzed values for diets of hospitalized individuals with eating disorders. A hypothetical patient with anorexia nervosa was served three meals a day for 15 days. A nurse would remove some of the food from the tray and freeze it for subsequent analysis. The tray was returned to the kitchen where trained personnel estimated the amounts eaten from each tray. Daily intake was established by analysis and by calculation from food composition tables, and the results were compared. They found good agreement between the two methods. Fat was overestimated by 5.4%, and protein was found to be underestimated by 1.1%. While the difference found for fat is larger than that for protein, the difference between calculated and chemically analyzed values for fat is less than is usually found for free-living populations. The authors suggested that this may be because persons with anorexia nervosa eat few, if any, combination dishes or foods high in fat, which simplifies calculation and results in greater accuracy of estimation.

DURATION OF THE RECORD

The duration of time the record is to be kept affects the accuracy of dietary information. A number of recent studies assessed the question of the minimum number of days necessary for sufficient accuracy. Jackson et al. (1986) had subjects keep 14-day food records and then analyzed all possible randomly selected combinations of 3, 4, 5, 7, 9 and 11 consecutive days out of the 14 for energy, cholesterol, saturated fat and polyunsaturated fatty acids. For records of 3, 4 and 5 consecutive days, they found that the percentages of sets within the 95% confidence limit of the 14-day mean ranged from 95 to 99% for each of the parameters chosen. Based on these results, they concluded that a four-day record would be acceptable for accurate information. However, since the only difference between the three- and four-day records was an increase from 96 to 97% of records within the 95% confidence limit of the 14-day mean for cholesterol, it would appear that a three-day record would provide adequate information about fatty acid intake.

Pao et al. (1985) used the information from 8,779 food records from the USDA Nationwide Food Consumption Survey (Spring, 1977) to evaluate one- vs three-day food records. The analysis was based on a one-day recall, a one-day combination of recall and estimated food record, and a one-day estimated food record. The combination of all three days was compared with the one-day food record to obtain their results. They found that a one-day intake measurement was sufficient to evaluate energy, carbohydrate, calcium, magnesium and phosphorus intakes for large groups. Fat, protein and some vitamins and minerals were less accurately estimated, and Vitamin A was poorly estimated using a one-day evaluation. For fat intake, at least three days were necessary for accurate estimation.

Using the same data from the USDA Nationwide Food Consumption Survey, Guthrie and Crocetti (1985) analyzed the extent to which nutrient intakes of individuals varies over a three-day period. They found that as much as 85% of the population had intakes of a specified nutrient on any one day that varied by more than 25% of the mean for the three days. They concluded that a one-day food record is of limited value in assessing calories, protein and selected vitamins and minerals. They suggested that at least three days are necessary for fat intake assessment.

Further work regarding the number of days of record-keeping required for maximum accuracy was reported by Stuff et al. (1983). Food records were kept for seven consecutive days by 40 lactating women. One day and three days were chosen randomly and intakes for fat, energy, protein, carbohydrate, calcium, phosphorus, and iron were compared. The three-day record showed a correlation coefficient of 0.74 when compared with the seven-day record for fat intake. Agreement was as good or better for the other nutrients. The one-day record showed a correlation coefficient of 0.46 with the seven-day record for fat intake. The authors concluded that the three-day record appeared to be a reasonable approach for obtaining nutrient intake data since three days represents the best compromise between obtaining accurate information and minimal imposition on the subject's lifestyle. Since three days showed an acceptable level of accuracy (Jackson et al., 1986; Stuff et al., 1983), the three-day record should result in an accurate estimate of fat intake.

It has been suggested that attempting to increase the accuracy by increasing the number of days during which food records are kept actually results in a decrease in accuracy because of the interference with normal lifestyles and, by inference, with usual intakes (Stuff et al. 1983). It is felt that unduly prolonging the record-keeping results in a loss of cooperation of the subjects and a decrease in accuracy (Chalmers et al. 1952; Young and Trulson 1960). Therefore, it would be preferable to use the minimum number of three days as is suggested by the literature (Jackson et al. 1986; Pao et al. 1985; Guthrie and Crocetti 1985; Stuff et al. 1983).

ANALYSIS OF FOOD RECORD INFORMATION

The information from food records is analyzed in two main ways: using food composition tables and using a computerized nutrient database. These may be used separately or in combination with each other. Some of the foods in the diet may be chemically analyzed in the laboratory and this information used in conjunction with the other methods.

Food composition tables are the main source of information for the analysis of diet records. The reliability of nutrient intake calculated from dietary record data and tables of nutrient values has been tested numerous times by comparing the calculated results to laboratory analyses. A study by Whiting and Leverton (1960) compiled the results of 29 studies from Canada, Britain and the United States which compared chemical analyses of duplicate samples and calculated analyses of weighed diets. For protein and calories, 54 and 58% of the studies, respectively, found that calculated values were within 10% of the analyzed values. For fat, however, only 25% of the studies fell within 10%. Fat was overestimated by more than 10% in 49% of the studies, indicating that total dietary fat seems to be poorly estimated, even when using weighed records.

There are some limitations to the use of food composition tables. USDA Handbook No. 8 (1963) is a widely used table of food composition. However, when using this reference to evaluate dietary intake, there are some factors to consider. Analysis is done on samples from specific geographical areas and therefore may not be representative of similar foods from different areas. New products such as lean Canadian beef and pork are not included in Handbook No. 8. Therefore, researchers in Canada must refer to other sources, such as the Canadian Nutrient Data File, for information on beef and pork. The nutrients included in Handbook No. 8 are also restricted to those for which analytical data exists. For example, revised Handbook No. 8 (1963; Supplements: 1976, 1979) does not contain data for all fatty acids for all foods. Foods which are not listed in the generally recognized as safe (GRAS) list are not included. Therefore, canola oil, although extensively used in Canada, has only recently been added to the GRAS list and is therefore not included in Handbook No. 8.

The information from food composition tables is currently being made available in computerized form. Computer databases are being used more frequently to calculate dietary intake data. A number of databases are available which contain nutrient information for a large number of foods. The use of a database makes possible faster processing of large amounts of information, fewer errors of individual calculation and access to information about more foods.

However, there are also some disadvantages to using a database for estimating fat intake. First, each database is generally programmed using a specific food composition table. Since the data contained in the tables may vary substantially (Eagles et al., 1966), comparisons between studies using different databases which do not share the same sources of information become less reliable. Second, updates of food composition data may not be processed immediately and cannot be incorporated with the same ease as when manually calculating nutrient intakes. A study by Shanklin et al. (1985) compared the information from two database systems, the NHANES II and the Nutrient Dietary Data Analysis using 60 diet records. Both of these systems used information based on USDA Handbook No. 8. Correlation coefficients between the two databases were 0.63 for linoleic acid and also were low for some other nutrients, such as iron and calcium. Shanklin et al. (1985) suggest that there are two main reasons for the differences. The speed with which database updating was accomplished resulted in one database containing more information than the other. Data entry errors accounted for the remaining differences.

When using databases or food composition tables to analyze diet information, it is essential for the nutrient information to reflect current foods. In addition, only the more common fatty acids are included for many foods. Nutrients for which insufficient data exist are assigned a "0" in database systems, resulting in the potentially false conclusion that these nutrients are absent. Thus, some of the less common fatty acids may be significantly underestimated. By contrast, food composition tables account for the absence of data with a dash which denotes that the information is missing, thus alerting the user to the possibility that the nutrient may in fact be present.

Comparisons have been made between the use of manual calculation using food composition tables and calculation using a computer database. A study by Eagles et al. (1966) reported a large range of differences between database and manually calculated values for three sample diets which were prepared at a Nutrition Clinic. Copies of the three diets were sent to eleven different nutritionists for nutrient calculation, resulting in a total of 96 utilizable observations. Calculation was done using three different food composition tables and by using a computerized nutrient database. It was found that fat, oleic acid and linoleic acid content were overestimated by all methods of calculation. Similar results were reported by Marshall et al. (1975) when diets containing 25% and 35% energy from fat were chemically analyzed or the nutrient content calculated using USDA Handbook No. 8 (1963). Oleic acid was overestimated by 35%

and 18:2 by 21%. The authors had no explanation for these discrepancies.

It is difficult to accurately estimate amounts of nutrients which are consumed primarily in complex food forms. Oenning et al. (1988) studied three different methods of estimating calcium and phosphorus in the diet. They analyzed 20 food records in four different ways: chemically; by calculation from food composition tables; by database calculation using a database called Nutritionist II; and by using an updated version of Nutritionist II called Nutritionist III. The results for calcium indicated good agreement for all methods. However, the three methods of calculation underestimated phosphorus by a mean of 272 mg when compared with the chemically analyzed values. Normal intakes of phosphorus are 800-1500 mg per day, so that an underestimation of 272 mg would mean an underestimation of phosphorus by 18-34%. The values obtained by calculation using food composition tables were slightly closer to the actual values than the values using the databases. No reason was given to explain the difference found between the manually calculated and database values.

The authors suggested that the reason for the underestimation of phosphorus is the increasing use of phosphate-containing food additives during processing. When only the menus containing highly processed foods were compared with the chemical data, the underestimation of phosphorus increased from a mean of 272 to a mean of 387 mg. Updated information on phosphorus-containing additives was not incorporated into the computer databases or food composition tables. Detailed information in the diet record will partially solve the problem. Fatty acid calculation may be analogous to phosphorus calculation, since fatty acid data in food composition tables and databases also is incomplete.

It is apparent from the studies assessing fat intake (Whiting and Leverton, 1960; Peterson et al., 1986), that fat intake is difficult to accurately quantitate. By inference, calculation of fatty acid intakes is at least as inaccurate (Eagles et al., 1966). Broadhurst et al. (1987 a) addressed the problem of calculating fatty acid intake using a computer database for mixed diets. They collected weighed food records and duplicate diets for 11 subjects on 16 consecutive days. The duplicate diets were chemically analyzed. Nutrient content of the weighed records were calculated by database: a) using only standard database codes; b) assigning two separate codes to fried and roasted foods, one for the food and one for the fat; c) by the use of extra data from the chemical analysis of a number of combination foods; and d) by a combination of both b) and c). They found that the last method provided results that agreed best with the chemically analyzed values. There was no significant difference between calculated and analyzed values for total polyunsaturates, monounsaturates and saturates and less difference for 18:2 and 18:3 than with the other methods. It is apparent from these results that detailed information is necessary for the accurate calculation of fatty acid intake.

There are several problems associated with the estimation of the intake of specific fatty acids. The lack of specific information in food composition tables, the alteration of fats in processing, and the lack of specific information about the fats contained in commercially prepared foods have contributed to difficulty in estimating fatty acids.

The information about fatty acids is incomplete in both the food composition tables and the databases. Until a few years ago, fatty acids were not studied intensely, so foods were not necessarily analyzed for fatty acid content. In food composition tables this is indicated as missing data. As mentioned previously, database systems assign a "0" to missing data leading to the false conclusion that the fatty acids are absent. Canola oil, which is an important source of 18:3, is the main oil on the Canadian market. However, this oil is not included in American publications and databases of food composition. Since these sources of information are frequently used to analyze dietary intakes for Canadians, 18:3, as well as 18:1 and 18:2 in the diet, may be substantially underestimated.

In addition, fatty acids are altered by food processing. An analysis of margarines by Beare-Rogers et al. (1977) pointed out that hydrogenation can change a substantial amount of the unsaturated fatty acids in an oil to its trans- form. The authors claim that the trans- form should not be included as polyunsaturated fatty acids, since their physiological action is similar to a saturated fatty acid. However, food composition tables usually do not distinguish cis- and trans- configurations.

A further difficulty encountered when obtaining information regarding the sources of fats used in the diet are labelling regulations that allow manufacturers to list fats as:

> Canola and/or Sunflower and/or Corn and/or Soybean;
>
> or
>
> Hydrogenated vegetable and/or animal fat shortening (may contain soybean oil, palm oil, beef fat, lard, coconut oil, cottonseed oil).

In instances like these it is difficult, if not impossible, to ascertain which fat is in the food. When determining the amount of fatty acids in the diet, it is important to know the source of the fats in the diet. Many products are labelled to indicate the specific fat content. The information available regarding the sources of fat in the foods consumed must be included in food records when collecting diet information for the calculation of fatty acid intake.

RELEVANCE OF FATTY ACID INTAKE MEASUREMENT

Recommendations for changes in population diets have focused on fat modification in order to prevent coronary heart disease. Renaud et al.(1986) found that increased 18:3 in the diet appears to increase the stability of platelets by increasing the membrane cholesterol content. The result is longer clotting times and decreased aggregation in response to thrombin. Similarly, a study by McDonald et al. (1989) showed that canola oil in the diets of normolipidemic men resulted in longer bleeding times. Prolonged bleeding potentially could be a problem for individuals with bleeding disorders such as those with von Willibrand's disease or platelet function defects. These individuals suffer from prolonged bleeding which seems to vary in severity at different times, suggesting that a variety of factors may affect bleeding, one of which may be diet. Specifically, the inclusion of increased amounts of 18:3 in the diet may result in longer bleeding times. This could potentially be extended to involve impaired wound repair in otherwise normal individuals (NIN Review, 1988).

As is apparent from the work by Broadhurst et al., (1987 b), an accurate estimate of the intake of 18:3 appears to be difficult to obtain. Accurate estimates of 18:3 could potentially contribute to the medical management of bleeding disorders and thrombosis. A diet record which will provide detailed information about fat intake is needed. Further, the record needs to contain information about the specific sources of fat in the diet to allow the calculation of the amounts of fatty acids consumed.

The objectives of the present study were twofold:

1. to develop a diet record that would provide more complete information regarding the sources and, where possible, the composition of the fats in the diets of free-living individuals; and

2. to compare two different methods of calculating the nutrient content from the information obtained in the food records with the chemical analysis of duplicate diets. The two methods were: a) calculation using food composition tables and food product information; and b) calculation using a computer program and a nutrient database without modification.

METHODS

FOOD RECORD

A food record designed to facilitate the calculation of fatty acid intake was developed (Appendix A). Detailed information which identified the sources of fats in the diet, processing methods, label information and portion sizes was sought in the food record. Special instructions were given to subjects to assist in recording the specific information required to describe the fat sources in the foods they consumed. Space was provided on the diet record sheet for the additional information. The food record was pre-tested with a group of 11 subjects who were employees of the Morden Hospital in Morden, Manitoba.

SUBJECTS

The food record was used in a study conducted in cooperation with Dr. Nathan Kobrinsky and Dr. Jon Gerrard, Department of Pediatrics and Child Health, Faculty of Medicine, University of Manitoba, Winnipeg. The effect of fatty acid intake on bleeding times was assessed in a group of subjects with bleeding disorders. A control group of subjects with no bleeding disorders consisted of family members and staff of the Cancer Treatment Centre of the Health Sciences Centre. The subjects consisted of males and females ranging in age from fifteen months to 45 years.

DIETS

Subjects were provided with two types of fats and all subjects consumed each fat in a cross-over design. One diet contained fats which were saturated, while the other diet contained fats that were unsaturated. The experimental design of the study required each subject to keep four three-day food records over the course of the study, two during each of the experimental periods. One three-day diet record was used to establish the baseline diet before each experimental period, and the other to assess fat and fatty acid intake during each of the experimental periods. When the subjects came to the Cancer Clinic of the Health Sciences Centre for the determination of initial baseline bleeding times, they were instructed in the method used in recording their customary diet for a three-day period.

In the first experimental period, which ran from October to December, 1988, approximately half of the subjects (both those with bleeding disorders and controls) were given foods rich in saturated fats, which included butter, Crisco shortening, Kraft mayonnaise, Kraft Creamy Cucumber dressing and Kraft Coleslaw dressing. The other half were given fats containing a high level of mono- and polyunsaturated fatty acids. These foods included West canola oil, Becel margarine, Kraft Golden Caesar dressing, Kraft French dressing and Newman's dressing. For the second experimental period, which ran from January to

March, 1989, the subjects received the opposite diet from the one they had been assigned in the first experimental period. One of the subjects had an allergy to dairy products and could not use butter, so Krona margarine was substituted for butter in the saturated diet.

The baseline food records, which were collected one day after they were completed, were reviewed with each subject to ensure that the necessary information had been included. The subjects were then given the experimental fats and told to substitute these for the dietary fats usually consumed. They also received another food record booklet in which they were to record food intake at the end of the four week experimental period. The subjects were contacted by telephone approximately one week before the end of the experimental period to make an appointment for the next bleeding time and to remind them to keep a record of their food intake. They were asked to bring the food record to the appointment when bleeding time was determined. The record was reviewed as previously for accuracy and completeness of information during the appointment.

The second experimental period began approximately three months after some of the subjects had completed the first experimental period and therefore it was felt that another baseline diet record was required prior to the second experimental period. The protocol for record keeping was reviewed. At this time six subjects, three from each experimental diet group, volunteered to collect duplicate samples of everything that was consumed on of the days during the three-day record period for both the baseline and the experimental periods. It was felt that the first two collection periods had provided a training period for the subjects, and that the information received during the third and fourth collection periods would have improved accuracy. The subjects were given plastic pails and were instructed to include everything except foods which were fat-free such as soft drinks, fruit juices, black tea and coffee, and to keep the pail in the freezer until it was collected to ensure that there were minimal changes to the fatty acids in the foods. Foods eaten away from home were also to be included in the collection of the duplicate. The volunteers were compensated for collecting the one-day duplicate.

ANALYSIS

Dietary intake was calculated for total fat and for fatty acids. USDA Handbook No. 8 (1963), together with supplements (1976, 1978, 1979), was used to calculate the fat and fatty acid content of food items such as: dairy products; cooking fats such as oils, shortenings, margarines, and salad dressings; fish; poultry; luncheon meats; and meats other than pork and beef. Pork and beef data from Agriculture Canada

(1988) was used to evaluate those meats. For mixed foods such as tacos, pies and pastries, canned soups and snack foods, such as candy bars, donuts, muffins and novelty items, information regarding the types of fats used was obtained from the labels and from the food processors. Information on the fatty acid composition of canola oil was obtained from research in the Foods and Nutrition Department, University of Manitoba (see Appendix B). Where data on the fat and fatty acid levels in foods was not available, decisions were made based on disappearance data for the sources of the fats in the food mixtures. Information also was obtained from McDonald's Restaurants and Robin's Donuts on the specific fats used by them (see Appendix C).

The one-day duplicates of the diets were homogenized and aliquots lyophilized. Total fat was extracted using the Bligh and Dyer method (1959). The fat was then methylated, using an adaption of the method by Shehata et al. (1970). A larger sample and more reagents were used. The fatty acid methyl esters of 16:0, 18:0, 18:1, 18:2 and 18:3 were separated by gas liquid chromatography using a Durabond-225 capillary column, 30 m x 0.25 mm, with a film thickness of 0.25 microns. Duplicate samples were analyzed for all procedures. The values obtained were converted to grams using the conversion factors of Posati (1976).

Database analysis of the food records was done using the Canadian Nutrient File (1988). Foods were coded according to the foods as listed in the code book without separating the ingredients in the combination dishes. For example, for pizza the code for pizza was used, rather than listing the meat and cheese separately. Five fatty acids (16:0, 18:0, 18:1, 18:2 and 18:3) were chosen for comparison between the analyzed values and the values calculated from the database analysis and from the food composition tables.

The records from the six subjects were treated as independent records to yield 12 observations. The results of the laboratory analysis for one of the subjects indicated an extremely low intake for total fat (<15g), which was appreciably lower than the manually calculated amount (40g). This discrepancy was assumed to have resulted because of the omission of some fat-containing foods from the duplicate collected for analysis. Therefore, this record was eliminated and 11 records were used for the statistical analysis.

The regression coefficients comparing the calculated data with the chemically analyzed values were calculated using Proc Reg in SAS. The 95% confidence limits of the data for each of the five fatty acids were calculated. Graphs were completed using Gplot in SAS/Graph.

RESULTS

The results reported herein and the discussion that follows assume that the laboratory values represent the most precise measure of the fat and fatty acid intakes by the subjects. The total fat and fatty acids for each of the 11 records were calculated in two ways: manually, using food composition tables and manufacturers' information (where available); and with a computerized database. The values obtained were compared with the results from the laboratory analysis.

The coefficients of determination (r^2) for the comparison of the manual and database calculations with the laboratory values are shown in Table 1. The r^2 values for the determination of total fat and fatty acids, with the exception of 18:2, indicate that both methods of calculating fat and fatty acids resulted in good estimates, with manual calculation yielding estimates that were somewhat closer to those obtained by laboratory analysis.

Major discrepancies among the manual and database calculations and the laboratory values for total fat and for the fatty acids were examined in detail to determine the reasons for the differences.

Table 1. Coefficients of determination for manual and database calculations compared to laboratory analysis.

Total fat and fatty acids	Coefficient of determination (r^2)	
	Manual	Database
Total fat	0.83	0.75
16:0	0.80	0.71
18:0	0.76	0.72
18:1	0.91	0.84
18:2	0.11	0.11
18:3	0.85	0.72

TOTAL FAT

The r^2 values (Table 1) for the two methods of calculating total fat indicate good agreement between the calculated values and the laboratory values. The manual method correlated somewhat more closely with the chemically analyzed values than the database method. The results of the analysis of total fat for each record by the three methods of determination: manual calculation; calculation using a computer database; and chemical analysis in the laboratory, are presented in Table 2.

Table 2. **Total fat in diets using three methods of determination.**

Record	Manual (g)	Database (g)	Laboratory (g)
1	32.0	19.3	27.3
2	79.2	97.9	76.4
3	48.5	35.6	35.7
4	28.2	38.2	23.5
5	42.5	59.9	54.3
6	26.7	37.4	27.0
7	54.5	40.9	34.2
8	101.7	112.9	76.1
9	88.1	96.7	86.5
10	51.8	51.9	32.3
11	88.6	82.7	92.3

The database values differed substantially from the manual and laboratory values for records 1, 2, 4, 6, 9, and 11. The selection of the food code could explain the differences found between the database calculations and the manual and laboratory methods for records 1, 2, 4, and 6. For record 1, the code used for pizza accounted for the smaller amount of fat calculated by the database. The fat content calculated by the database method contained half the amount of fat indicated by the manual calculation. This accounted for a difference of 13g between the two methods. The pizza was commercially prepared, with beef and cheese toppings. The code chosen for the database calculation was "pizza: chilled, baked". The more appropriate code as indicated by the total amount of fat in the diet would have been "pizza: from home recipe, baked, with sausage topping". For the manual calculation of fat for pizza, the amounts of beef and cheese used were estimated from a recipe. (The foods for each record are listed in Appendix C.)

For record 2, no food code for pecan loaf was listed in the database. A code for Danish pastry was used to substitute for the pecan loaf. The Danish pastry contained 14g of fat according to the database, while the pecan loaf contained 7g fat according to the manual calculation. This would account for a portion of the 18g difference between the database value and the manually calculated value. The remaining 11g could not be explained on the basis of the foods in the record.

The database value for record 4 was 10g more than the value obtained using manual calculation. The record did not identify the kind of ham consumed. The database code selected was for ham containing the bone, which yielded 18g fat, whereas boneless ham was used for the manual calculation, which yielded 8g fat. The higher estimate of the amount of total fat contributed by the ham using database calculation compared with the manual calculation would account for the 10g difference between the two methods of calculation.

The database calculation was also higher for record 6. This may be attributed to the food code used for chicken noodle soup. The subject consumed home-made soup, which contained 4g fat according to the manual calculation from a recipe. In the database calculation no code was available for homemade chicken noodle soup. The food code selected was for canned, ready-to-serve chicken noodle soup. Calculation of fat by the database method yielded 13g fat, which would account for most of the 10g difference between the manual and database values.

The reason for the differences between the database and the manual and laboratory values for records 9 and 11 was not known. For record 9 the database calculation was approximately 10g more than the manual and laboratory values. For record 11 there was less fat in the database calculation than by the other two methods. These differences could not be attributed to any particular food items in the food records.

Manual calculations were noticeably different from the database and laboratory results for records 3 and 5. Record 3 indicates that manual calculation resulted in higher values for total fat. The higher amount was due primarily to the amount of fat contained in the gravy prepared by the subject. The amount of fat in the gravy was calculated using the value for beef gravy from the Nutrient Values of Some Common Foods (1988). The database code for gravy was for canned gravy which was found to contain almost no fat. The difference between the two calculated values amounts to 10g of fat. If this amount were subtracted from the manual calculation, then the methods would agree.

The manual calculation yielded a lower value for total fat for record 5. A portion of the difference between the manual calculation and database and laboratory methods may be attributed to an error in the estimation of the amount of ham consumed. The value using the manual calculation should agree with the laboratory results if the ham was responsible for the entire difference among the three values.

For record 7 there was no agreement among any of the methods. In this case, one meal was eaten outside the home. Decisions had to be made about the fat content of clam chowder, peanut butter, Cornish game hen and cheesecake. A portion of the difference between the calculated values for fat was attributed to the differences in the fat contained in the clam chowder. The recipe used for the manual calculation of the amount of fat in the soup yielded 13g and the database calculation resulted in 6g fat. While this did not account for the total difference, the soup appeared to be one of the foods which contributed a significant amount of fat to the total fat in the diet. A portion of the remaining difference may be due to the cheesecake consumed by the subject. The cake was eaten outside the home, and therefore a recipe was not available. For the manual calculation, the ingredients and their proportions were determined using a standardized recipe. The database did not contain a code for cheesecake and cream cheese was substituted in the same amounts used in the standardized recipe. It appears that the substitution may have elevated the fat content of the diet when the laboratory value was considered. In the record, the peanut butter was reported to contain hydrogenated canola oil, but the amount of fat added during processing was not known. Nutrient analysis of Cornish game hen was not available in the food composition sources used, and a roasted broiler was substituted. It was not possible to determine if the substitution yielded accurate information.

For records 8 and 10, the manual and database calculations agreed well with each other, but the laboratory results were substantially lower than the calculated amounts. The results for these records indicate that both the manual and database calculations for total fat in the diet were higher than the laboratory analysis by approximately 20 to 30g. No single food item in the food records appeared to have contributed to this difference. It is possible that either the food record did not reflect actual intake, or that the subjects did not include all the foods recorded in the duplicate of the diet.

FATTY ACIDS

The coefficients of determination (r2) for the individual fatty acids determined by manual and database methods and compared to values determined by laboratory analysis are depicted in Figures 1-5. The values obtained by each of the three methods for each fatty acid appear in Tables 3-7.

PALMITIC ACID

Figure 1 contains the results of the analysis for 16:0. The r^2 values for the manual and the database methods of calculation compared to the analyzed values (see Table 1) indicate that the values obtained using manual calculation yielded a more accurate estimation of 16:0. As shown in Figure 1, a number of the values obtained using the two methods of calculation are in close proximity to each other for each record, indicating relatively good agreement between the two methods of calculating 16:0.

Differences among the three methods were apparent for five records. As shown in Table 3, the results for record 1 indicate that the database calculations yielded a value of 0g for 16:0. Two food items constituted the total diet for that day which were pizza and a muffin, both commercially prepared. An examination of the database revealed that no value was available for 16:0 in the database for either pizza or muffins.

Figure 1.

PLOT OF LAB BY PREDICTED

SHOWING 95% CONFIDENCE INTERVALS FOR MEAN PREDICTED VALUES
SYMBOL FOR MANUAL +
SYMBOL FOR DATA BASE *
FAT=16

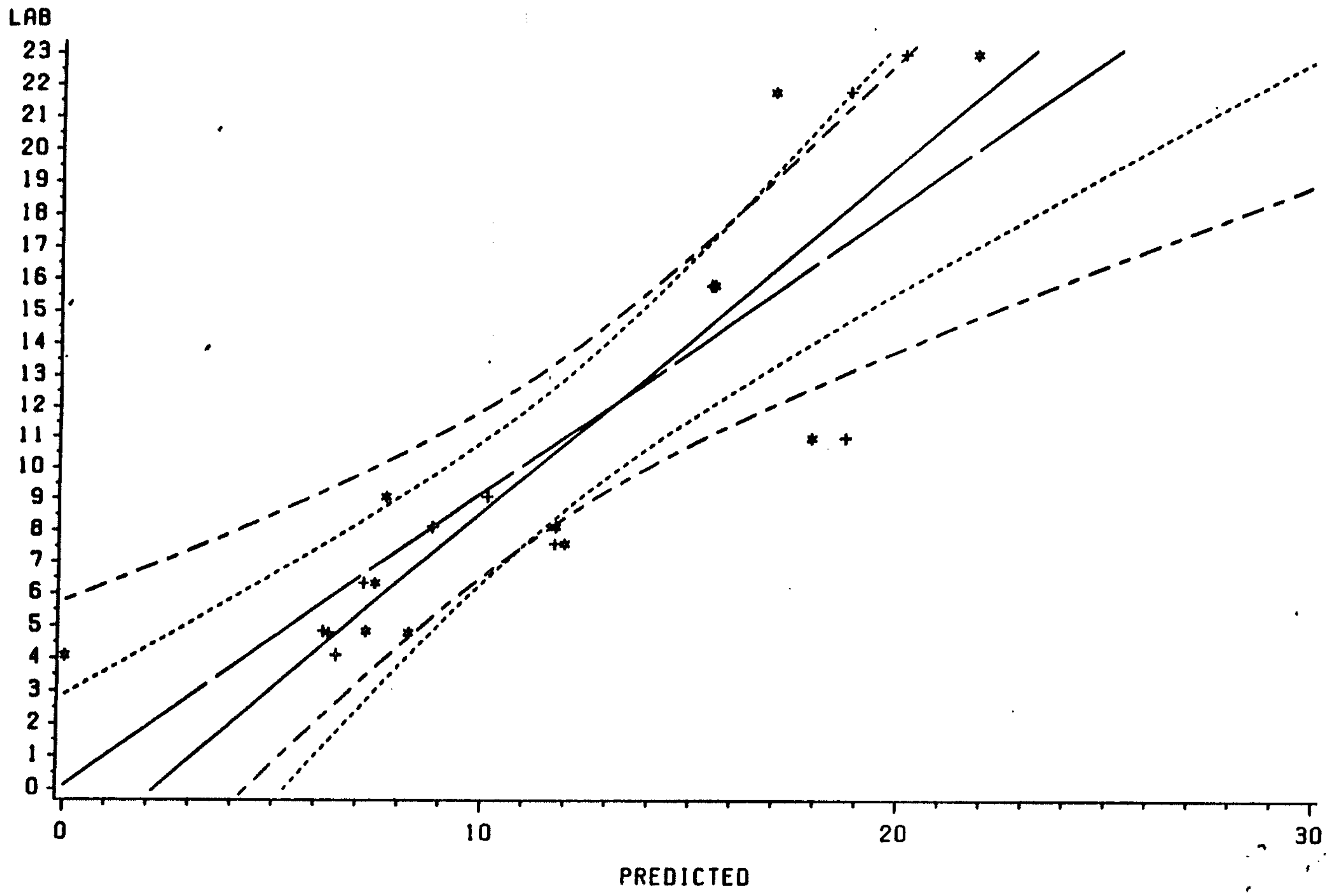


Table 3. Values for 16:0 using three methods of determination.

Record	Manual (g)	Database (g)	Laboratory (g)
1	6.5	0.0	4.1
2	15.4	15.5	15.7
3	10.1	7.7	9.0
4	6.3	8.2	4.8
5	8.8	11.7	8.1
6	6.2	7.2	4.8
7	7.1	7.4	6.3
8	18.7	17.9	10.9
9	20.0	21.7	22.9
10	11.9	12.0	7.5
11	18.7	16.9	21.7

Records 4 and 5 indicate that the database calculation resulted in higher values for 16:0 than the manual calculation and the laboratory analysis. For record 4 this was consistent with the results for total fat, for which the database calculation resulted in higher values for the ham coded as bone-in. The reason for the difference found between the database and the other two methods for record 5 is not known.

The results of the laboratory analysis for records 8 and 10 are lower than the calculated methods. This coincides with the results found for total fat.

STEARIC ACID (18:0)

The coefficients of determination for 18:0 are similar for both methods of calculation as shown in Table 1. Figure 2 shows the plot of the calculated values against the chemically analyzed values. Except for records 1, 4, 5,and 6, the values for the two methods were similar. The database calculation resulted in a greater number of values outside the 95% confidence limits.

As indicated in Table 4, the results for record 1 show 0g of 18:0 by the database calculation method. As for 16:0, this was due to the absence of values for 18:0 for pizza and muffins in the database.

Figure 2.

PLOT OF LAB BY PREDICTED

SHOWING 95% CONFIDENCE INTERVALS FOR MEAN PREDICTED VALUES
SYMBOL FOR MANUAL + ———— --------
SYMBOL FOR DATA BASE * —— —— —·—·—
FAT=18

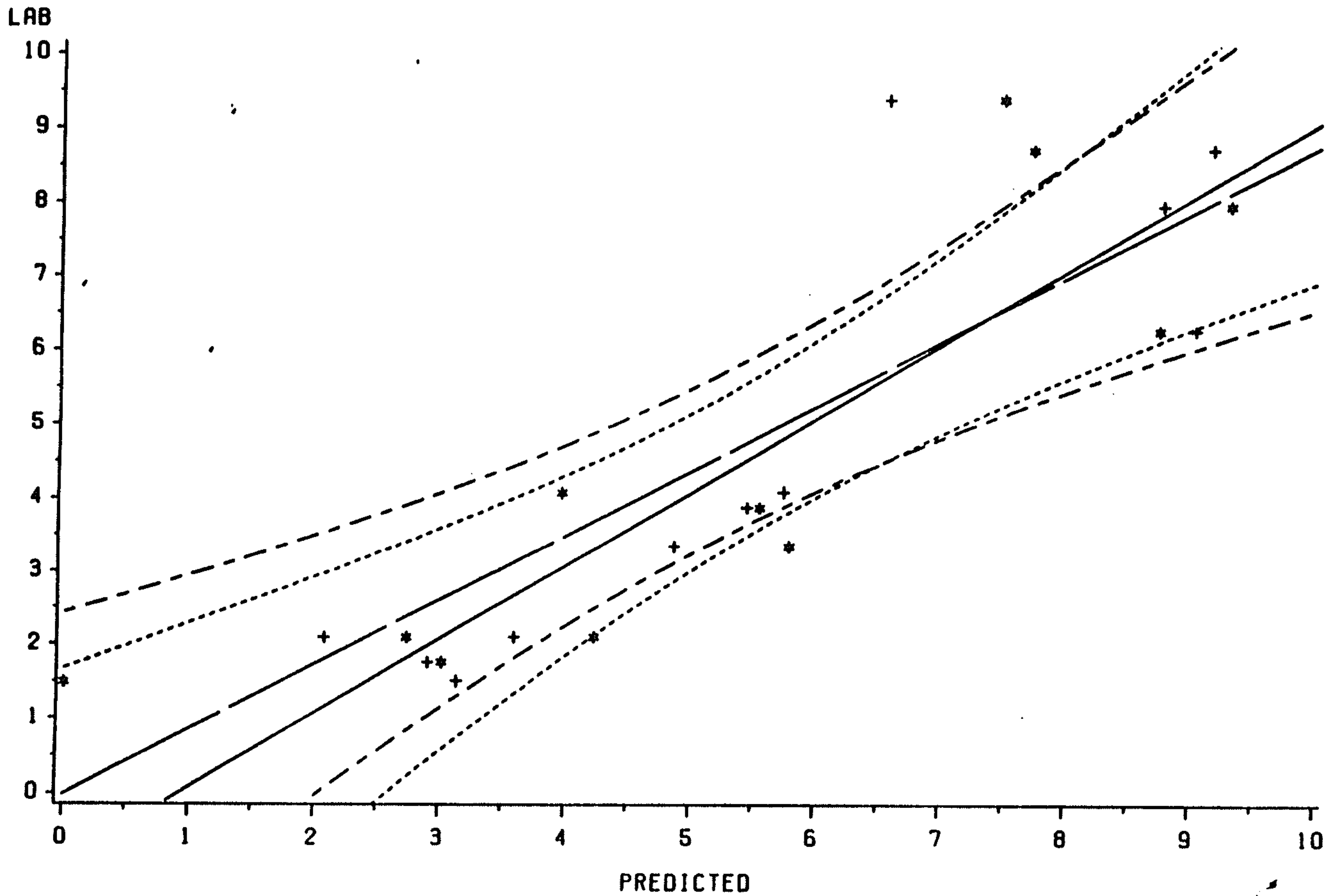


Table 4. Values for 18:0 using three methods of determination.

Record	Manual (g)	Database (g)	Laboratory (g)
1	3.1	0.0	1.5
2	6.5	7.5	9.4
3	5.7	4.0	4.1
4	3.6	4.2	2.1
5	4.9	5.8	3.3
6	2.9	3.0	1.7
7	2.1	2.7	2.1
8	9.0	8.7	6.2
9	8.8	9.3	7.9
10	5.4	5.5	3.9
11	9.1	7.7	8.7

The calculated values were approximately double the values for the laboratory values for records 4, 5, and 6. For records 4 and 6, this difference would coincide with the values for total fat. There is no satisfactory explanation for record 5.

OLEIC ACID (18:1)

Figure 3 depicts the results for of the analysis for 18:1. There was good agreement between the calculated methods and the laboratory analysis. The majority of values were within the 95% confidence limits. As observed previously for 16:0 and 18:0, manual calculation resulted in values that agreed more closely with the laboratory values than the values calculated by the database method.

Table 5 contains the results for all records for the determination of 18:1. The database calculation differed from the manual calculation and laboratory analysis for records 1, 5, and 6, but the differences are similar to those found for total fat. Record 1 indicates a lower value of 18:1 for the database calculation. For records 5 and 6, 18:1 was substantially higher for the database calculation than for either the manually calculated or the laboratory values.

The laboratory values for records 8 and 10 are lower than the calculated values. Again, these values coincide with the lower values found for total fat in the laboratory analysis for these two records since the proportions of oleic acid were similar.

Figure 3.

PLOT OF LAB BY PREDICTED

SHOWING 95% CONFIDENCE INTERVALS FOR MEAN PREDICTED VALUES
SYMBOL FOR MANUAL +
SYMBOL FOR DATA BASE *
FAT=18.1

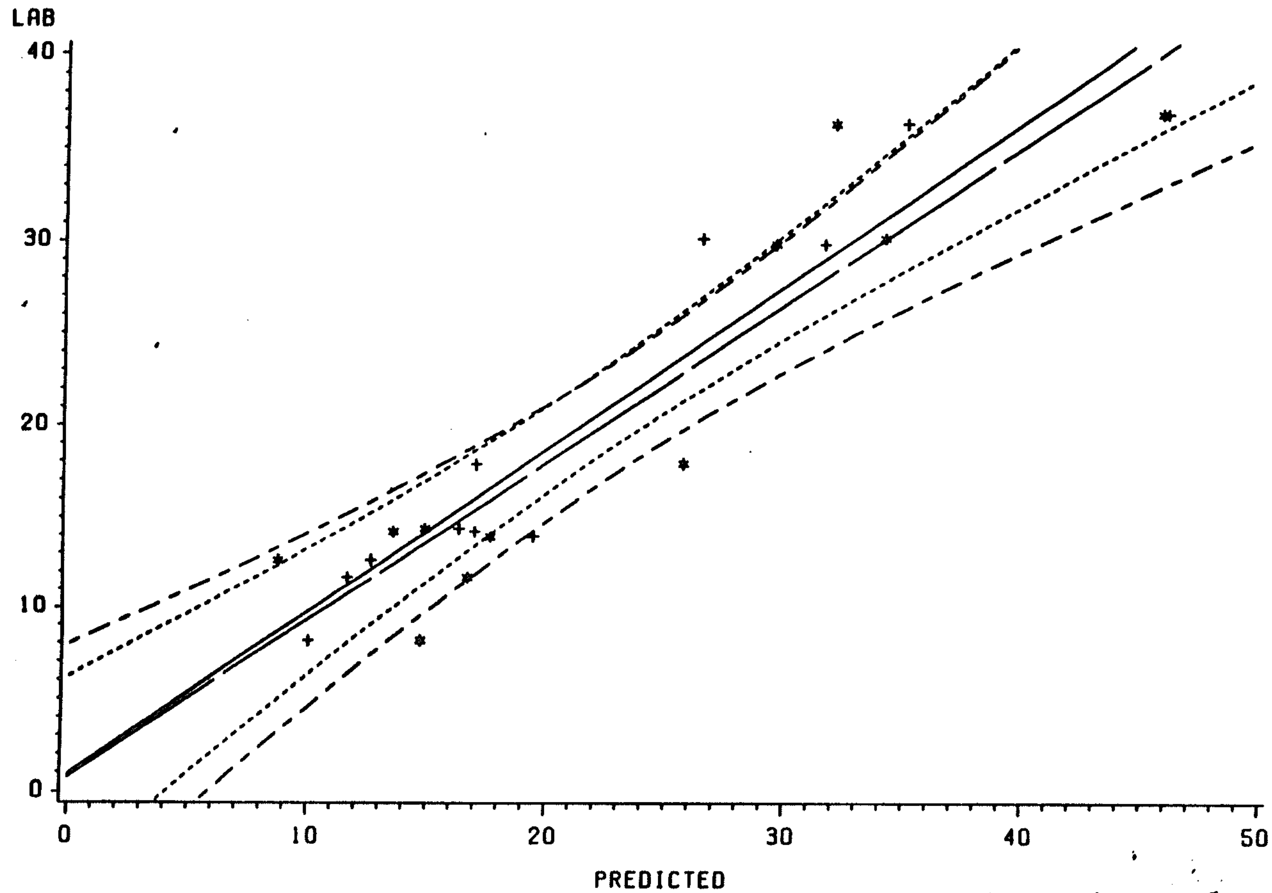


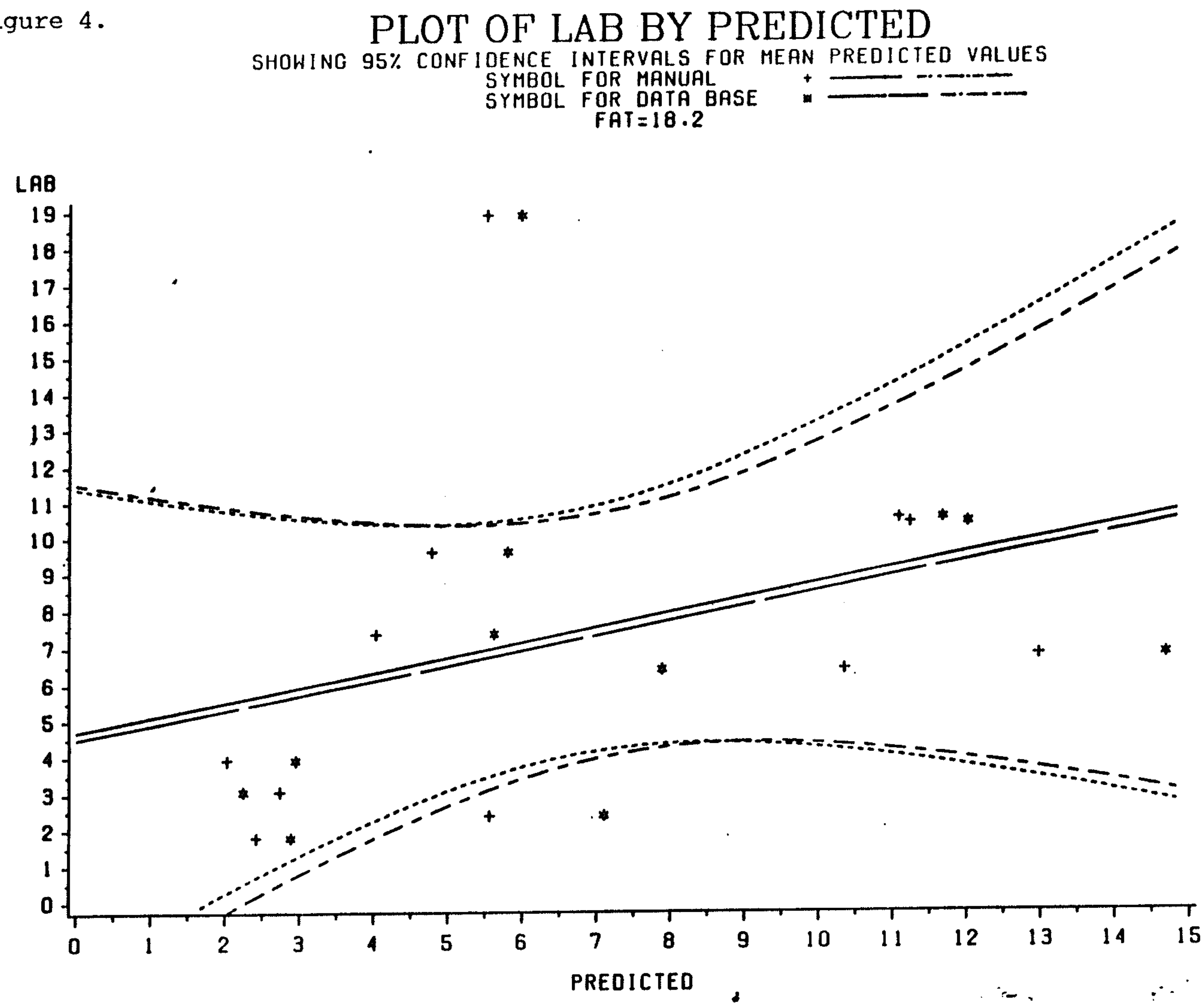
Table 5. Values for 18:1 using three methods of determination.

Record	Manual (g)	Database (g)	Laboratory (g)
1	12.6	8.7	12.6
2	26.4	34.1	30.0
3	16.9	13.5	14.1
4	11.6	16.7	11.6
5	17.0	25.7	17.7
6	10.0	14.7	8.1
7	16.3	14.9	14.3
8	45.9	45.7	36.7
9	31.5	29.5	29.7
10	19.4	17.6	13.8
11	34.9	32.9	36.2

LINOLEIC ACID (18:2)

The coefficients of determination for 18:2 signify that neither method of calculation provided a satisfactory estimate of the values obtained by the laboratory analysis. In Figure 4, a number of the calculated values did not agree with the laboratory values. Large differences between the calculated values and those obtained by laboratory analysis were found for records 2, 5, 6, 7, and 9 as shown in Table 6.

Figure 4.


PLOT OF LAB BY PREDICTED
SHOWING 95% CONFIDENCE INTERVALS FOR MEAN PREDICTED VALUES
SYMBOL FOR MANUAL +
SYMBOL FOR DATA BASE *
FAT=18.2
LAB
0
1
2
3
4
5
6
7
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9
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11
12
13
14
15
16
17
18
19
PREDICTED

Table 6. Values for 18:2 using three methods of determination.

Record	Manual (g)	Database (g)	Laboratory (g)
1	2.0	3.0	3.9
2	13.0	14.7	6.7
3	2.7	2.3	3.1
4	2.4	2.9	1.8
5	5.5	6.0	18.9
6	4.8	5.8	9.6
7	10.3	7.9	6.4
8	11.2	12.0	10.3
9	4.0	5.6	7.3
10	5.6	7.1	2.4
11	11.1	11.7	10.5

For records 7 and 9, the differences found between the calculated values and the laboratory values may be attributed to meals eaten outside the home. Both subjects ate one meal outside their home for which they did not have access to recipes and ingredients. Decisions were made about the amount of fat present in some of the foods consumed and the source of the fat(s) present. These foods included clam chowder, peanut butter, Cornish game hen, and cheesecake for record 7 and chocolate cake for record 9. For the clam chowder and the peanut butter which contained unspecified fats in record 7, decisions about the kinds of fats used were based on disappearance data. The fat in the chocolate cake in record 9 was calculated as butter. Although the cake was consumed outside the home, the subject believed that the person preparing the cake would have used butter.

The remaining records containing large differences were not explainable on the basis of the foods present in the records. For record 2, the amount of 18:2 was higher for both the manual calculation and database calculation than for the chemical analysis. In the food record, the subject reported that 14g of corn oil was used for frying meatballs. It is speculated that a significant amount of this fat was not absorbed by the meatballs. If 50% of the 8g of 18:2 present in the corn oil was not absorbed, it would result in a decrease of 4g of 18:2 in the calculation methods. This would also result in 7g less total fat for the calculated results and would yield calculated values that would be closer to the laboratory values for total fat.

For records 5 and 6, the laboratory values indicated substantially more 18:2 than the calculated values. The reasons for these differences were not apparent, as the food records did not indicate that there were any good sources of 18:2. At the time of the collection of the duplicate, a sunflower margarine, a food source rich in 18:2 was being used in both homes. It may be speculated that some of the margarine was included in the diet duplicates, and was not listed in the food record. This could account for the discrepancy between the calculated methods and the laboratory results.

LINOLENIC ACID (18:3)

The r^2 values for the manual calculation of 18:3 indicated that manual calculation resulted in a more accurate estimate of 18:3. Figure 5 shows the results obtained when the calculated values were plotted against the laboratory values for 18:3. While most of the calculated values agreed fairly well with each other, several deviated widely from each other.

As shown in Table 7, for four of the records, 1, 4, 7, and 9, there were substantial differences among values obtained by the three methods. For record 1, the database value for 18:3 was 0g. This was again due to the absence of values in the database for 18:3 for pizza and muffins. The manual calculation and the laboratory analysis also differed. This difference may be due to the kind and amount of fat used in the preparation of the foods consumed.

Figure 5.

PLOT OF LAB BY PREDICTED

SHOWING 95% CONFIDENCE INTERVALS FOR MEAN PREDICTED VALUES
SYMBOL FOR MANUAL +
SYMBOL FOR DATA BASE *
FAT=18.3

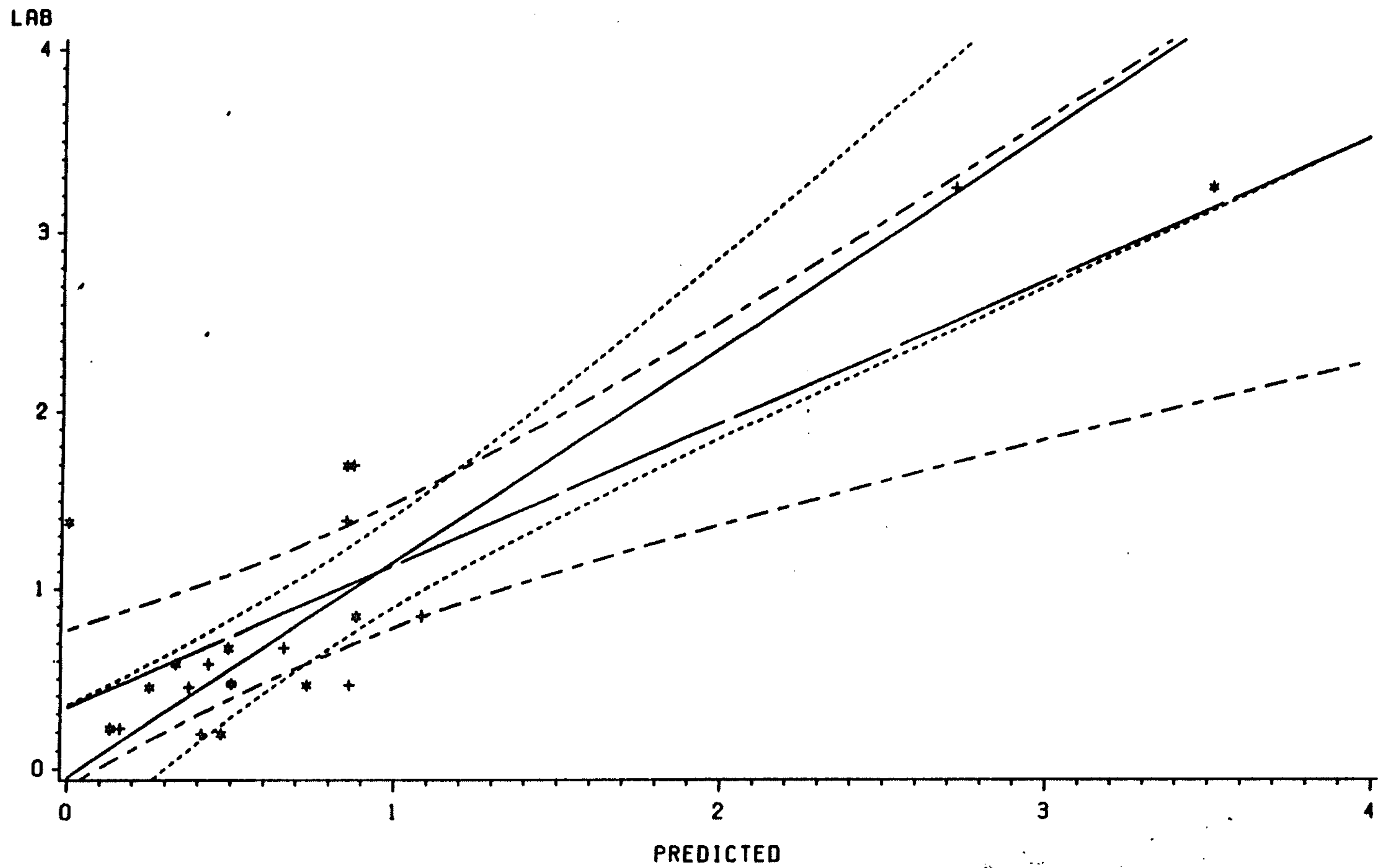


Table 7. Values for 18:3 using three methods of determination.

Record	Manual (g)	Database (g)	Laboratory (g)
1	0.9	0.0	1.4
2	0.7	0.5	0.7
3	0.4	0.3	0.5
4	0.4	0.5	0.2
5	0.5	0.5	0.5
6	0.2	0.1	0.2
7	0.4	0.3	0.6
8	2.7	3.5	3.2
9	0.9	0.9	1.7
10	0.9	0.7	0.5
11	1.1	0.9	0.8

The laboratory values for records 4, 7, and 9, differed from the two methods of calculation. Record 4 contained lower levels of 18:3 on analysis than those obtained by calculation, which would be consistent with the lower levels of total fat found for record 4. For records 7 and 9, more 18:3 was determined by the laboratory analysis than by the calculated methods. As was noted for 18:2, this may again be due to foods eaten outside the home for which the ingredients and their amounts were not known. The difference found for record 9 for 18:3 also was found for 18:2 and may be explained by the substitution of an oil for butter in the chocolate cake. For example, if canola oil had been used instead of butter, it is estimated that one portion of cake would contain an additional 1.0g of 18:3. The total amount of 18:3 according to the manual calculation would then be 1.9g, compared with 1.7g according to the laboratory analysis. This is based on 15g fat in one portion of cake. The use of an oil in place of butter may not noticeably affect the remaining fatty acids, since the remaining foods in the record have a high proportion of saturated fats.

DISCUSSION

The coefficients of determination indicated that the fatty acids calculated by both manual and database methods in the present study differed from the laboratory values. This result is similar to those found by Eagles et al. (1966) and Marshall et al. (1975). They found that both methods of calculation of fatty acid intake overestimated 18:1 and 18:2 relative to the laboratory analysis. Both studies used sample diets that were provided by the researcher and prepared in advance for clients/subjects and for which the fat sources could be identified. The study reported here, however, asked subjects consuming self-selected diets to identify fat sources from product labels. Therefore, there was less information about the actual fats consumed.

Differences were also found between the methods of calculating total fat and fatty acids. The database calculations were found to be more variable than the manual calculation using food composition tables together with additional information.

SOURCES OF INFORMATION ABOUT FATS IN FOODS

The descriptive information available about foods is important in assessing fatty acids intakes, since accurate information about fatty acid intake depends on the identification of the sources of the fat in the food. Information is obtained from the subject, food processors and restaurants, the food record, and the interviewer. Although an effort was made in this study to obtain more complete information about fat intake, there are still limitations in the collection of data about dietary fat intake and the calculation of fat and fatty acids.

Subject error is difficult to control. The subject must be taught to estimate and record food intake accurately. When collecting duplicate meals, the exact amounts of foods consumed are assumed to be in the duplicate. In the case of record 5, the subject was a 12 year old for whom the mother made the duplicate meals. Hence it is possible that either the record or the duplicate did not simulate actual intake. Similarly, while both methods of calculating total fat and fatty acid intakes for records 8 and 10 were in agreement, there was an overestimation of all parameters, except 18:3 for record 8, relative to the laboratory values. It is possible that either the amount of food recorded by the subject overestimated the amount actually consumed or the amounts included in the duplicate were inaccurate.

Another type of error may have occurred in the case of food record 2. The subject assumed that the amount of the corn oil used for frying the meatballs had all been absorbed by the fried food. Laboratory analysis of the duplicate meal was lower for 18:2 than for the calculated intakes, suggesting that the amount of fat absorbed was significantly less than the amount recorded. It may not be possible to entirely eliminate this type of error, since fat absorption during frying is variable and depends on factors such as the temperature of the fat, the degree of saturation of the fat used (Yang and Chen, 1979), the amount of time the food is in contact with the fat (Stevenson, et al., 1984) and the nature of the food. This kind of error is common to foods cooked in fat.

Subject error may also have been the main contributor to the surprising lack of agreement between the calculated and chemically analyzed values of 18:2. Major sources of 18:2 are limited to a few foods, namely vegetable oils. However, the amounts of 18:2 are appreciably different in canola and soybean oils. These oils are commonly used in the food industry. Canola contains approximately 20% 18:2 and soybean 54%. Unless the oil source is identified, considerable error could be made in estimates. In addition, errors by the subjects in recording or measuring the amounts of foods which are good sources of 18:2, or errors in preparing the duplicate, could result in significant differences between the calculated amounts and the laboratory values.

Like linoleic acid, 18:3 also is present in a limited number of foods, particularly soybean and canola oils. However, better r^2 values were obtained for 18:3 than for 18:2. Linoleic acid is present in varying amounts in a greater variety of plant oils than 18:3, and may therefore be more difficult to accurately identify. The better estimates for 18:3 may also be due to some of the decisions made about the fats used in processing. It was assumed that soybean and canola oil, which contain similar amounts of 18:3, were the main sources of fats used by manufacturers and restaurants.

The use of convenience foods, processed foods and snack foods was a confounding factor with both methods when calculating fat and fatty acid intakes. Convenience foods are those which contain a number of ingredients and are prepared outside the home. In the food records these were muffins, pizza, canned soups and peanut butter. While the ingredients may be listed on the package in terms of relative weight, the actual weight of the various ingredients are not given.

The use of disappearance data to determine the specific fat used in processing did not always correctly assess fatty acids in individual cases. The fats contained in these foods are often listed simply as "vegetable oil" or "hydrogenated vegetable oil". Even when the generic name of the added oil is given, the amounts contained in the food are not specified.

Thus decisions have to be made regarding the sources and amounts of the fat or fat-containing ingredients in the food to permit the calculation of the amounts of the fatty acids contained in the diet. In the present study, decisions related to the types of fats used were based on disappearance data (see Appendix D). It was apparent from the laboratory analysis of the duplicate diets that these decisions were not always correct. The differences found between the analysis of fatty acids for diets which included canned soups and peanut butter, and the calculated methods, suggested that the fats used in the processing were not necessarily those which were expected. Fats added to commercially prepared foods include both saturated fats such as palm oil, coconut oil, and hydrogenated soybean oil and unsaturated fats such as canola oil, peanut oil, and soybean oil. Hence, a wide range of fatty acids may be present in these foods.

For some of the foods accurate information regarding the fats used was obtained either from the label or from the manufacturer. With this information, it was possible to supplement the food composition tables. Foods consumed by our subjects for which this information was obtained include: Weston's products, Becel margarine, McCain's products, Kraft products and some snack foods: Old Dutch products and Robin's Donuts (Appendix D). This factor may contribute to the higher coefficients of determination (r^2) for the manual calculation as compared with the database calculation in this study. This information could also be taken into account using a database, and would involve coding the individual foods in mixed dishes separately, one of the methods used by Broadhurst et al. (1987 b).

The difficulty in estimating nutrients in diets containing processed foods was noted by Oenning et al. (1988) in the estimation of phosphorus. These investigators followed a similar procedure to that used in the present study. They found that the database and manually calculated methods underestimated the amount of phosphorus compared to levels determined by laboratory analysis. This difference was attributed to the use of phosphorus-containing additives in processed foods. It seems apparent from the present study that fatty acids are equally poorly estimated for processed foods. Since processed foods make up a significant part of many self-selected diets, it is difficult to assess fatty acid intakes in free-living populations. More precise labelling of the individual components would assist the researcher in assessing fatty acid intake. It should also be noted that for some processed foods, standardization of serving size and/or ingredients provides more accurate information for the determination of nutrients. One example of this is the use of processed cheese slices. Another is the standardization of fat used in products such as Becel margarine.

The frequency of eating outside the home also is a problem when assessing fat intakes. This is especially difficult for meals eaten in restaurants, where knowledge about ingredients and the amounts used may not be available. Fats used in food preparation vary among restaurants and with the kind of food being prepared. For example, McDonald's uses a combination of beef tallow and cottonseed oil for French fries, corn and cottonseed oil for other deep-fried foods and butter for eggs. (McDonald's switched to canola oil for deep-fried items in January, 1990.) For restaurants where food preparation is not standardized, the fats used are determined by availability and competitive prices. As was noted for processed foods, standardization of food preparation could provide information about fat sources and amounts. However, since this kind of information is not yet readily available, it is more difficult to accurately determine fatty acid intake from foods consumed in restaurants.

Ethnic foods are becoming more popular, both at home and when eating out. The frequent use of these foods has increased the complexity of calculating fat and fatty acid intake since the ingredients and their proportions are often difficult to identify. Consequently, the amount of fat consumed may be calculated incorrectly.

Finally, even though the subjects have been taught to provide details about the fats in the diet, the interviewer must be aware of potential omissions. The lack of adequate descriptions of food items in a food record may be detected by a skilled interviewer when reviewing the record with the subject. The gravy reported in record 10 did not include instructions about the method of preparation. Also, the large amount of 18:2 in the laboratory analysis for records 5 and 6 suggested that a sunflower margarine may have been used but not included in the records. Further probing by the interviewer at the time of the collection of the food record may have detected these errors.

FOOD COMPOSITION DATA

In order to assess dietary record information for fat and fatty acids, the food composition data must include a description of the fat used in the foods included in the food composition tables and databases. Specific information on the sources of the fats was not available in the food composition data for many of the foods consumed by subjects in the present study. A number of foods did not appear in the Canadian Nutrient Database or in Handbook No. 8. The foods which were listed often contained fatty acid data, but did not specify the fats contained in the food. For some foods the data in the database was incomplete for fatty acids such as 16:0, 18:0 and 18:3.

Incompleteness of the list of foods in the food composition table and the database contributed to inaccuracy when estimating fat and fatty acid intake. Foods which had no reasonable equivalents in the food composition tables or the database included Mexican specialty foods (tacos, enchiladas, burritos, tortillas), some snack foods (ice cream drumsticks, cherry sandwiches, taco chips, chocolate-covered granola bars), some foods which are consumed infrequently (kippers and Cornish game hen), desserts (cheesecake) and some salad dressings (Caesar dressing). Most of these foods frequently appeared in food records of the subjects in the present study and contributed significant amounts of fat to the diet. Ideally the sources used in assessing nutrient intakes should contain foods which reflect habitual food patterns. Since the North American diet includes a rapidly increasing variety of processed and ethnic foods and snack items, it is difficult to maintain an updated source of food composition information.

Neither Handbook No. 8 nor the Canadian Nutrient File was a complete source of fatty acid composition of foods. As has been mentioned, some foods were not included in the food composition tables or database which were available to the researcher. These foods need to be chemically analyzed to determine their total fat and fatty acid content. For some foods, such as romano cheese, no fatty acid information was available in either the database or the food composition tables, even though data was presented for other nutrients in the cheese. Also, information for some foods was not available in Handbook No. 8. Information about the fatty acid content of nuts, chocolate and the 1988 analysis of Canadian pork and beef were taken from the database.

The incomplete data for fatty acids for some of the foods in the database contributed to the greater variance between the database calculations and the laboratory analysis. As was noted by Shanklin et al. (1985), "0" values are assigned to those fatty acids for which no information is available and these fatty acids are then underestimated when standard coding methods are used. For example, only two fatty acids, 18:1 and 18:2, were listed for pizza and muffins. Since these two items constituted the food intake for the day one subject, the database calculation resulted in zero values for the remaining fatty acids. For chocolate only values for 18:1, 18:2 and 18:3 are present in the database. Both pizza and chocolate contain significant amounts of saturated fatty acids. Muffins are often made with oil and in Canada this oil is likely to be canola, which would contribute appreciable amounts of 18:3 to the diet. Since the amount of 18:3 in the database is given as "0", a significant underestimation of 18:3 can result if foods, such as muffins, are a frequent item in the diet. The researcher must be aware of omissions of this type when using a database to analyze diets for fatty acid consumption.

The discrepancies found when comparing the database calculations with the manually calculated values can be further attributed to problems encountered in coding the data. For instance, the appropriate codes to be used for ham and pizza were difficult to determine. Several different codes were available, but the appropriate code only became apparent in retrospect when compared with the laboratory analysis of the diet. When coding foods for calculation using a database, sufficient information about food composition is needed in order to make the best choice. Users of databases must be very familiar with the particular foods contained in the database and with the composition of the foods in the record.

Another difficulty encountered in using the database was the lack of identity of the source of the fat(s) used in preparing the commercial foods. Fatty acid data was available for bread, peanut butter and commercially prepared soups. However, the fats contained in the foods were not described in the coding book. The manufacturer has considerable freedom as to which fats they might use in manufacturing these foods. This may result in differences when the calculated values are compared to laboratory analysis of these foods. Discrepancies due to processed foods using unidentified fats were noted in several records.

Similar problems with regard to the use of databases have been noted in the literature. Broadhurst et al. (1987, a, b) used 176 weighed diets and their duplicates from 11 subjects consuming self-selected diets. They analyzed 20 of the most frequently occurring foods for which no fatty acid data was available. These consisted mainly of processed and snack foods, which were significant sources of fat in the diets. This information was added to the database in order to obtain more accurate fatty acid information. However, it is not always possible or practical for the researcher to chemically analyze foods and some reasonable decision about the fat sources and amounts must be made. Adding fatty acid data into the database for an unlimited number of foods is not necessarily practical or possible.

CONCLUSIONS

The subjects who collected duplicate meals were a group of two males and four females, between the ages of 12 and 41 and represented the subjects for whom food records were collected in the larger sample. The diets were typical of the diets recorded by the larger group in that meals were eaten both at home and away. A variety of fat sources were consumed including meats, milk and milk products, oils and oil products and processed and restaurant foods. The sample size was small, however, which may affect the interpretation of the results. The independent observations yielding 11 food records rather than six replicated records also affects the statistical strength of the results obtained, since the individual error of any one subject may have been repeated.

The goal of the food record was to obtain information that would accurately reflect dietary fat intake. The results of the calculation, whether from food composition tables, or with a computer database, should have provided data that was a reflection of what the subject consumed.

The problem of identifying fat sources is part of the reality of the food choices which form an important part of self-selected diets. These diets include a significant number of meals eaten away from home, convenience foods and snack foods, for which the proportions of ingredients and sources of fat are unknown. While the subjects can be taught to carefully read labels and menu items to identify the sources of fat in the diet, the labels and menus still may not identify the particular fat(s) used. Informative labelling would contribute to the accuracy of fatty acid estimation.

The lack of information about fat sources and methods of preparation by restaurants makes estimation of fatty acid intake difficult. However, the larger franchises, such as McDonald's, have introduced standardized methods in food preparation and are using standard fat sources. The Heart Smart program has also improved estimates of fat and fatty acid intake in that the total amount of fat and type of fat can be more accurately estimated for meals eaten in participating restaurants.

There does not seem to be any single satisfactory source of fatty acid composition of foods. Therefore, to obtain more accurate estimates of fats and fatty acids in the diet, both the database and food composition tables, together with information from the manufacturers, need to be used. The information from manufacturers and composite data derived from several sources could temporarily be entered into a database for research.

The coefficients of determination for total fat and fatty acid intake were indicative of good agreement between the methods of calculation and the laboratory analysis. However, the differences found between the manual calculation and the database were somewhat surprising. The Canadian Nutrient File uses USDA Handbook No. 8 as its main source of nutrient information, with the exception of the use of the 1988 Canadian beef and pork values. Since the manual calculation used printed tables of nutrient data from Handbook No. 8, as well as the nut, pork and beef data from the database, it was assumed that the results of the two methods of calculating fat and fatty acid intakes would agree fairly closely.

There were a number of reasons for the greater variability in the database calculations. First of all, missing data for some of the fatty acids for some foods was assigned a "0" value. This resulted in an underestimation of those fatty acids.

Secondly, based on the differences between the laboratory and manual determination and the database calculation, it was found that coding difficulties contributed to the inaccuracies found. When using a database, the code selected is based on the descriptors, not on the values of certain nutrients. When examining the values retrospectively, it was found that the food codes selected were not the most appropriate. The errors can be seen retrospectively if the researcher is very familiar with the composition of the foods or has access to the values in the database and is able to compare these values to a laboratory analysis of the food. Therefore, when using a database to calculate fat and fatty acids, it is important for the coding to be done by an individual knowledgeable about the database and food composition in general.

Thirdly, the unspecified fat ingredients in the database are one of the contributing factors to the differences found between the two methods of calculation. It would be useful to the researcher for the database to specify which fats were used in the analysis of food product.

The lack of agreement between the estimates and the laboratory values of 18:2 was also unexpected and may in part have been due to the small sample size. Large differences in several of the food records contributed substantially to the variation. A contributing factor may be the small number of foods which contain large amounts of 18:2, making individual errors larger. When this factor is coupled with the limited amount of information available regarding the fat sources in the diet, exaggerated differences occur. Linolenic acid is similar to 18:2 in that it is found in appreciable amounts in only a few foods, but the r^2 values for the calculation methods compared with the laboratory analysis were indicative of good agreement.

When obtaining information about the fat and fatty acid intakes of a population, good descriptive information is available when the individuals prepare the foods in the home. However, it is more difficult to obtain accurate information when subjects consume commercially prepared foods. The database provides an adequate resource for the calculation of fatty acid intakes for population surveys. For metabolic studies or intervention trials, the researcher should employ manual calculation of fatty acids, using a combination of food composition tables, databases, manufacturers' information and potentially, chemical analysis of the major fat sources. The one exception, based on the present study, is for 18:2. Neither Handbook No. 8 nor the Canadian Nutrient File provided adequate information for estimating the intake of linoleic acid.

BIBLIOGRAPHY

Beare-Rogers, J. L., Gray, L. M., and Hollywood, R. The linoleic and trans fatty acids of margarines. Am J Clin Nutr 32: 1805-9, 1979.

Bligh, E. G. and Dyer, W. J. A rapid method of total lipid extraction and purification. Can J Biochem Physiol 37: 911-17, 1959.

Broadhurst, A.J., Stockley, L., Wharf, S. G., Faulks, R.M., and Penson, J. M. Validity of calculating fatty acid intake from mixed diets. Hum Nutr: Appl Nutr. 41A: 101-6, 1987 (a).

Broadhurst, A. J., Wharf, S. G., and Stockley, L. Fatty acid composition of selected foods consumed in a mixed diet study. Hum Nutr: Appl Nutr 41A: 96-100, 1987 (b).

Chalmers, F. W., Clayton, M. M., Gates, L. O., Tucker, R. E., Wertz, A. W., Young, C. M., and Foster, W. D. The dietary record - how many and which days? J Am Diet Assoc 28: 711-16, 1952.

Eagles, J. A., Whiting, M. G., and Olson, R. E. Dietary appraisal - problems in processing dietary data. Am J Clin Nutr 19: 1-9, 1966.

Ferro-Luzzi, A, Strazzullo, P., Scaccini, C., Siani, A., Sette, S., Mariani, M.A., Mastranzo, P., Dougherty, R.M., Iacono, J. M., and Mancini, M.Changing the Mediterranean diet: effects on blood lipids. Am J Clin Nutr 40: 1027-37, 1984.

Guthrie, H. A. and Crocetti, A. F. Variability of nutrient intake over a 3-day period. J Am Diet Assoc 85: 325-7, 1985.

Health and Welfare Canada. Canadian Nutrient File, 1988.

________. Nutrient Values of Some Common Foods, 1988.

Jackson, B., Dujovne, C. A., Decoursey, S., Beyer, P., Brown, E.F., and Hassanein, K. Methods to assess relative reliability of diet records: minimum records for monitoring lipid and caloric intake. J Am Diet Assoc 86: 1531-5, 1986.

Liu, K., Stamler, J., Dyer, A., McKeever, J., and McKeever, P. Statistical methods to assess and minimize the role of intra-individual variability in obscuring the relationship between dietary lipids and serum cholesterol. J Chron Dis 31: 399-418, 1977.

McDonald, B. E., Gerrard, J. M., Bruce, V. M., and Corner, E. J. Comparison of the effect of canola oil and sunflower oil on plasma lipids and lipoproteins and on in vivo thromboxane A_2 and prostacyclin production in healthy young men. Am J Clin Nutr 50: 1382-8, 1989.

Marshall, M. W., Iacono, J. M., Young, C. W., Washington, V. A., Slover, H. T., and Leapley, P. M. Composition of diets containing 25 and 35 per cent calories from fat. J Am Diet Assoc 66: 471-81, 1975.

Murphy, E. W., Watt, B. K., and Rizek, R. L. Tables of food composition: availability, uses, and limitations. Food Technology, 40-51, 1973.

National Institute of Nutrition. Fish oils and health. NIN Review No. 7, 1988, October.

Oenning, L. L., Vogel, J., and Calvo, M. S. Accuracy of methods estimating calcium and phosphorus intake in daily diets. J Am Diet Assoc 88: 1076-8, 1988.

Pao, E. M., Mickle, S. J., and Burk, M. C. One-day and 3-day nutrient intakes by individuals - Nationwide Food Consumption Survey findings, Spring, 1977. J Am Diet Assoc 85: 313-24, 1985.

Peterson, R., Kaye, W. H., and Gwirtsman, H. E. Comparison of calculated estimates and laboratory analysis of food offered to hospitalized eating disorder patients. J Am Diet Assoc 86: 490-2, 1986.

Posati, L. P., Kinsella, J. E. and Watt, B. K. Dairy Products. Comprehensive evaluation of fatty acids in foods. J Am Diet Assoc 66: 482-8. 1975.

Renaud, S., Godsey, F., Dumont, E., Thevenon, C., Ortchanian, E., and Martin, J. L. Influence of long-term diet on platelet function and composition in Moselle farmers. Am J Clin Nutr 43: 136-50, 1986.

Shanklin, D., Endres, J. M., and Sawicki, M. A comparative study of two nutrient data bases. J Am Diet Assoc 85: 308-13, 1985.

Shehata, A. Y., de Man, J. M., and Alexander, J. C. A simple and rapid method of preparation of methyl esters of fats in milligram amounts for gas chromatography. Can Inst Food Technol J 3: 85-9, 1970.

Sirtori, C.R., Tremoli, E., Gatti, E., Montanari, G., Sirtori, M., Colli, S., Giafranceschi, G., Maderna, P., Dentone, C. Z., Testolin, G., and Galli, C. Controlled evaluation of fat intake in the Mediterranean diet: comparative activities of olive oil and corn oil on plasma lipids in high-risk patients. Am J Clin Nutr 44: 635-42, 1986.

Steele R. D. G. and Torrie, J. H. Principles and Procedures of Statistics. 2nd ed. McGraw-Hill, 1980.

Stevenson, S. G., Jeffrey, L., Vaisey-Genser, M., Fyfe, B., Hougen, F. W. and Eskin, N. A. M. Performance of canola and soybean fats in extended frying. J Food Sci 49: 187-194, 1984.

Stuff, J. E., Cutberto, G., Smith, E. O., Nichols, B. L., and Montandon, C. M. A comparison of dietary methods in nutritional studies. Am J Clin Nutr 37: 300-6, 1983.

Watt, B. K. and Merrill, A. L. Composition of foods, Agriculture Handbook no. 8, Agricultural Research Service, United States Department of Agriculture, 1963.

________. USDA Handbook no. 8-4, Fats and Oils, 1979.

________. USDA Handbook no. 8-1, Dairy and Egg, 1976.

________. USDA Handbook no. 8-5, Poultry Products, 1979.

Whiting, M. G. and Leverton, R. M. Reliability of dietary appraisal: comparisons between laboratory analysis and calculation from tables of food values. Am J Publ Health 50: 815-23, 1960.

Yang, C. S. and Chen, T. C. Yields of deep-fat fried chicken parts as affected by preparation, frying conditions and shortening. J Food Sci 44:1047.

Young, C. M. and Trulson, M. F. Methodology for dietary studies in epidemiological surveys. II - strengths and weaknesses of existing methods. Am J Publ Health 50: 803-14, 1960.

FOOD INTAKE RECORD

Dietary Fat Assessment

Department of Foods and Nutrition
University of Manitoba

DIRECTIONS FOR COMPLETING THE THREE-DAY FOOD RECORD

GENERAL INSTRUCTIONS:

- Please use the attached pages to record your food and beverage intake for the days indicated.
- It is important that you record everything you eat and drink, at home and away from home.
- Describe each food item and the amount eaten. Some suggested ways of measuring foods are included on the next page.

.../3

Suggested Way of Measuring Foods:

Food	Measurement
- Milk, etc. (whole, 2%, skim, in tea, coffee, on cereal)	- cups, tablespoons, teaspoons or ml
- Cereals (dry, cooked, presweetened)	- cups, tablespoons or ml
- Potatoes (mashed, boiled, fried, chips)	- cups, small or large size, number of fries
- Bread (white, brown, whole wheat, rye)	- slices, large or small loaf
- Biscuits, rolls, buns	- number, size and type
- Meat	- slices, ounces, dimensions
- Fruit	- number and size, or cups
- Vegetables	- cups or number, eg. 1 carrot
- Sugar	- teaspoons or tablespoons or ml
- Condiments (jam, jelly, ketsup, etc.)	- tablespoons or teaspoons, ml
- Sweets (candies, chocolate)	- number of pieces or size of package
- Beverages (soda pop, alcoholic beverages, juices)	- cups or ounces, ml (low calorie product)

SPECIAL INSTRUCTIONS:

In your description, please make sure that all oils and fats are described as fully as possible, using the following guidelines:

1. For fats and oils such as butter, margarine, shortening, salad dressings:

    a) the brand name and the kind of product, eg. Kraft Catalina dressing
    b) the name(s) of the oil(s)/fat(s), eg. hydrogenated vegetable oil (may contain soya oil, palm oil, cottonseed oil, coconut oil)
    c) the amount of polyunsaturates and saturates, eg. 27% polyunsaturates, 18% saturates
    d) solid or soft margarine - "brick" or "tub"
    e) hydrogenated.

2. For all dairy products, such as milk, cream, cheese, ice cream:

    Give the percent fat if stated on the package, eg. milk, 2% milk fat (M.F.) or 2% B.F. (butter fat), cream, 18% M.F.

3. The following foods are sources of fat and should be listed (check labels carefully):

    Egg/egg yolk, sour cream, buttermilk, seeds (eg. sunflower, sesame), nuts, chocolate, avocado, whipped toppings, non-dairy creamers, peanut butter (some add oil as well).

4. Include recipes for homemade baked goods, soups, sauces and gravies where possible.

.../4

5. Meats, beef, pork and poultry:

   a) luncheon meats should include the meat source, eg. salami: pork and/or beef.
   b) specialty meats include organ meats such as liver, and bacon, which should be described as side or back bacon.
   c) fresh meat should be described as follows:
      i) retail cut and weight
      ii) an estimate of any fat trimmed and not used
      iii) an estimate of the amount of fat added to cooking, eg. boneless rump roast, 2.15 kg, untrimmed, browned in 2 tablespoons oil and roasted.

6. Fish should be described as:

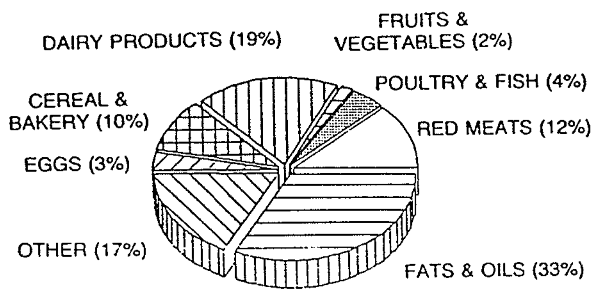
   The kind of fish, whether fresh, frozen or canned; if battered/breaded and deep fried; if canned, whether oil was used in canning.

.../5

SOURCES OF DIETARY FATS:

Fats are found in a variety of foods. The amount of fat in particular food catagories also varies widely. The following diagram shows the sources and relative amounts of fat in the average Canadian diet in 1986.

Sources of dietary fat, average Canadian, 1986



The largest source of fat in our diets is added fat in the form of butter, margarine, oil, shortening. One-third of our fat intake comes from fats added to foods in cooking and baking and as spreads.

Perhaps surprisingly, the next largest category is dairy products, which form 19% or nearly one-fifth of our total fat intake. Besides milk, this group includes foods such as ice cream, cheese, whipped cream and yogurt.

While red meats are often popularly believed to be a major source of fat in our diets, the diagram indicates that meats such as beef, pork, lamb, are responsible for only 12% of the fat we eat.

The "other" category, which at 17% comes close to providing as much fat as dairy products, includes nuts, seeds, salad dressings, mayonnaise and snack foods (eg. chocolate).

Fruits and vegetables are not normally thought of as containing fat. However, there are some exceptions: for instance, soybeans, avocados and olives contain substantial amounts of fat.

SAMPLE FOOD RECORD

Food Item	Amount/ Descr.	Method of Cooking Preparation	Brand,Kind	Fat Composition
Breakfast:				
apple juice	1/2 cup		Dairymaid	
Rice Krispies	2/3 cup		Kelloggs	
milk	1/2 cup		Modern	2% MF
sugar	1 tsp			white,granulated
bread, 100% wholewheat	1 slice	toasted	George's bakery	vegetable oil shortening, may contain palm oil
margarine	1 tsp		Becel,tub	liquid sunflower oil, modified palm and palm kernal oil, 55% polyunsaturates, 25% saturates
honey	1 tsp			
Lunch:				
mushroom soup	1 cup	milk added (2% MF)	Campbells	hydrogenated vegetable oil
soda crackers	2		No Name, Super-Valu	hydrog. veg. &/or animal fat shortening, may contain: soybean oil, palm oil, beef fat, lard, coconut oil, cottonseed oil
tuna sandwich				
bread,white	2 slices		Fort Garry Bakery	as above
mayonnaise	1 tsp		Kraft,Light	vegetable oil, egg yolk, whole egg, 32 g fat/ 100 g
tuna	1/4 cup		Albacore	packed in hydrogenated soya oil
butter	1 tsp			
lettuce	1 leaf		iceberg lettuce	
milk	1 cup		skim	
orange	1 small		fresh	

Food Item	Amount/ Descr.	Method of Cooking Preparation	Brand,Kind	Fat Composition
Snack:				
chocolate bar	1 - 69.5 g		Hershey's - Oh Henry	roasted peanuts, modified palm & vegetable oils, chocolate, hydrogenated coconut oil
Dinner:				
chicken	1 drumstick 1 thigh	dipped in flour,deep fried	whole fryer, cut up	
oil for frying			Crisco	canola and/or modified hydrogenated soya oil
french fries	30 fries	oven baked	McCain	vegetable oil
coleslaw	1/2 cup			
dressing	1 tablespoon		Kraft, coleslaw lite	vegetable oil, egg yolk, 10.1 g/100 g
coffee	1 cup			
powdered cream	2 tsps		Carnation	hydrogenated vegetable (may contain coconut)
ice cream	1/2 cup		Good Humor butterscotch ripple	milk solids, butter
Snack:				
apple	1 medium			
cheese	1" cube		Armstrong - Gouda	28% MF

FOOD ITEM	AMOUNT/ DESCRIPTION	METHOD OF COOKING PREPARATION	BRAND/KIND	FAT COMPOSITION

APPENDIX B.

Analysis of canola oil at the University of Manitoba.

Fatty acid	Amount in 100g
14:0	0.1
16:0	4.3
18:0	2.0
16:1	0.2
18:1	62.0
18:2	20.1
18:3	8.0
20:1	1.7
22.1	0.3

APPENDIX C.

Fat-containing foods identified in the diet records.

Record	Amount (g)	Food
1	50	pumpkin muffin
	210	pizza
2	16	powdered coffee creamer
	8	butter
	65	danish pastry
	21	processed cheddar cheese
	83	white bread
	411	split pea soup
	11	soda crackers
	185	lean ground beef, well-done
	14	corn oil
	3	parmesan cheese
	25	egg
	18	romano cheese
	7	pecans
3	197	milk, 2%
	60	whole wheat bread
	15	side bacon, broiled
	170	cross-rib roast
	25	egg
	36	beef gravy
4	153	milk, 2%
	60	white bread
	30	side bacon, broiled
	100	ham

5	120	white bread
	10	cheddar cheese
	245	milk, 2%
	200	ham
	22	peanut butter
6	50	egg
	30	white bread
	5	margarine, sunflower tub (Becel)
	70	milk, 2%
	516	chicken noodle soup, homemade
	90	ground beef, lean, well-done
7	32	peanut butter
	57	chicken breast
	258	New England clam chowder
	57	Cornish game hen
	15	whole milk
	50	cheesecake
	3	cheddar cheese
8	306	milk, 2%
	12	powdered coffee creamer
	32	mayonnaise, Kraft
	57	round steak, broiled
	22	side bacon, broiled
	118	egg
	60	bread
	10	butter
	170	ground beef, lean, well-done
	1	soybean oil
	120	rolls
	20	iced brownie

9	30	whole wheat bread
	20	butter
	260	milk, 2%
	113	egg
	31	process cheddar cheese
	56	turkey roll, light
	80	ground beef, lean, well-done
	6	parmesan cheese
	56	cheddar cheese
	69	un-iced chocolate cake
	15	whipping cream, 35%
10	122	milk, 2%
	57	garlic sausage
	66	pork loin, centre cut, well-done
	115	mushroom soup, undiluted
	15	butter
11	120	white bread
	16	peanut butter
	551	milk, 2%
	100	egg
	66	pork loin, centre cut, well-done
	115	mushroom soup, undiluted
	100	garlic sausage

APPENDIX D.

Fat content of commercial foods.

1. Breads and other baked goods
   all breads (except Weston's): hydrogenated soy shortening
   *Weston's bread and buns: cocoa butter
   other donuts
   *Robin's Donuts: Canola oil
   commercial muffins: Canola oil
   cakes: hydrogenated soy shortening
   cookies: palm oil
   soda crackers: palm oil
   other crackers: coconut oil
   buns, rolls (except Weston's): lard
   croutons: hydrogenated soy oil

2. French fries and snack foods
   *McDonald's (and other restaurants): 70% beef tallow and 30% cottonseed oil
   No Name Brand french fries: canola oil
   *McCain's french fries: canola oil
   chocolate bars: milk chocolate
   granola bars: cocoa butter
   *Old Dutch products: 80% sunflower oil and 20% canola oil
   other potato chips and related snack foods: soybean oil

3. Margarines, salad dressings and peanut butter
   Krona: hydrogenated soybean oil
   margarines with unknown fat sources: 40% canola oil, 36% soybean oil and 4% palm oil
   Crisco: hydrogenated soybean shortening
   *Kraft salad dressing (and other dressings, unless stated otherwise): canola oil
   Newman's dressing: olive oil and soybean oil
   *Kraft peanut butter: canola oil
   other peanut butter: as stated or palm oil

4. Miscellaneous
   Chinese restaurants: canola
   non-dairy powdered coffee creamer: coconut oil
   *McDonald's (other than french fries): 70% corn oil and 30% cottonseed oil
   ice cream: 10% fat (minimum amount of fat required by regulation)
   commercial soups: 80% soybean oil and 20% palm oil

* based on information received from the manufacturer