GENERATING NUTRIENT DATA

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INTRODUCTION

The importance and awareness of nutrition in public health issues has resulted in increased demands for knowledge of the nutrient content of foods. This knowledge is required by scientists conducting research in such areas as nutrition, food science, clinical chemistry and epidemiology. Dieticians and other professionals responsible for formulating diets are requesting detailed information about the nutrient content of foods. Food industry personnel and government officials concerned with nutrient labeling and other nutrition-related programs also have an increased need for detailed nutrient composition data.

Quantification of all of the nutrients important to human health in all of the available foods is an overwhelming, if not impossible, task. A conservative estimate of about one million analyses would be required to quantify a reasonable number of nutrients in a few representative samples of each of the generic food items available in the United States. A substantial base of nutrient composition information currently exists; nonetheless, data on many nutrients in many foods are unavailable. Budgetary and manpower constraints require that priorities be determined for nutrients to be analyzed and for the foods to be selected for nutrient analysis.

The purpose of this paper is to outline methods of establishing priorities for generating nutrient composition data. Such factors as the selection of nutrients and the selection of foods for analysis will be discussed. Progress that has been made in generating nutrient composition data will also be highlighted.

SELECTION OF NUTRIENTS FOR ANALYSIS

There are several reasons for quantifying nutrients in foods. These include research in plant and animal genetics, modifications in post-harvest technology, research in food science, food product development and nutrient composition analysis, per se. In the case of those research areas primarily concerned with nutrient analysis, there must be a rational approach to the selection of the nutrient(s) to be analyzed. Stewart (1981a) recently outlined such an approach; it is shown schematically in Fig. 1. The square represents the large domain of all nutrients. Within the large domain, there are three smaller domains, represented by circles, that correspond to: 1) nutrients associated with public health problems, 2) nutrients for which data are inadequate, and 3) nutrients for which analytical methods are good.

The overlap of all three smaller domains, represented by region 1 (Fig. 1), corresponds to those nutrients for which it is appropriate to generate nutrient composition information, i.e., those nutrients related to public health problems for which there are adequate methods but inadequate data. Region 2 in Fig. 1 represents those nutrients of public health concern for which there are inadequate data and inadequate methods. The nutrients contained in this region are those nutrients that should receive high priority research on analytical methodology. The nutrients represented by the other regions have a lower priority for nutrient analysis. A discussion of each domain and region follows.

Nutrients and Public Health

Standards of intakes for individual nutrients which are intended to protect the population against deficiencies have been developed in many countries. In the U.S., these standards are published as Recommended Dietary Allowances (RDA); the most recent edition appeared in 1980 (Nutrition Research Council, Food and Nutrition Board, 1980). Despite the RDA guidelines, several diseases and disease states may, in part, be caused by an inadequate or excessive intake of a nutrient or nutrients. The contribution of nutrient intake to U.S. public health problems is tabulated in Table 1. The assessment of the contributions is general in nature and intended to reflect the concerns of the nutrition research community for the free-living population. Inclusion of a nutrient in the category "None known" implies that an association between these nutrients and a public health problem has not been raised. It does not imply that the nutrient is not required or that it has no biological function. Inclusion of a nutrient in the category "Suspected" indicates that a respected research nutritionist has voiced concern about a public health problem associated with that nutrient, whereas, inclusion in the "Accepted" category means that many professionals, including physicians and nutritionists, generally accept a relationship between a nutrient and a public health problem. It does not imply that a relationship between the nutrient and a public health problem has been proven.

Knowledge of Nutrient Composition of Food

The United States Department of Agriculture has collected and disseminated data on the nutrient content of foods for many years. This activity is currently vested in the Nutrient Data Research Branch, Consumer Nutrition Division of the Human Nutrition Information Service. Scientists in this branch have recently re-evaluated the state of knowledge on the nutrient content of foods; the results of their most recent evaluation are shown in Figures 2-9.

Careful examination of Figures 2-9 reveals that a considerable amount of nutrient content data is available for commodities. These data have resulted, in part, from the research effort in such disciplines as plant and animal genetics, food science and technology, post-harvest physiology and agriculture engineering during the past two decades. Analytical information gathered for nutrient labeling has also contributed to these data. During the past few years, a considerable volume of new nutrient content information has become available; see Stewart (1980) for the state of knowledge of nutrient composition in early 1980. This phenomenon can be primarily attributed to the public demand for these data and the response to that demand as a result of the awareness of nutrition in public health problems.

Nonetheless, nutrient composition information is lacking for several food groups and for several categories of nutrients. A dearth of information exists for those food groups consisting primarily of highly processed or manufactured foods, i.e., baked products, snack foods, etc. Changes in the lifestyle of Americans during the past quarter century have resulted in the proliferation of convenience foods (fast foods, frozen dinners, restaurant food, etc.) for which limited nutrient composition data are available. In the case of entire categories of nutrients, biological effects and requirements have only recently been described. For some nutrients, lack of knowledge of their level in foods must be attributed to the lack of accurate, precise and inexpensive analytical methods. The complexity of foods, the multiplicity of the chemical forms of the nutrients, and the sensitivity required for quantitation place special demands upon analytical methodology and the analyst.

Analytical Procedures for Nutrient Analysis in Foods

Evaluation of existing methods.-Valid analytical procedures are essential for reliable nutrient analysis of foods. Only trained analysts using accurate and precise analytical techniques can acquire reliable data on the nutrient content of foods. If analytical techniques are inadequate, then even data collected by trained analysts should be questioned and as a result, resources may be wasted. The state of methodology for the analysis of nutrients in foods is tabulated in Table 2. The boundary between acceptable and unacceptable methods lies between substantial and conflicting states of methodology (Stewart 1980, 1981a). Thus, if appropriate methods are used by trained analysts, values will probably be correct for nutritionally significant levels of those nutrients listed as having adequate and substantial methodologies. In the case of most of the other nutrients, it is doubtful that valid results can be obtained during routine analysis. For these nutrients, different methods generally yield different values. Nonetheless, for a few of the nutrients in the conflicting and lacking category, reliable values may be obtained if extreme care is exercised by the analyst. There are also some very promising new methods in these categories and hopefully they will be quickly validated and adopted.

Accuracy and precision of the resulting data were used to classify the state of methods for nutrient analysis of food (Table 2). As suggested by Stewart (1981a), the analytical value should be within 10% of the true value when the nutrient of interest is present at nutritionally significant levels (greater than 5% of the RDA per standard serving or daily intake, whichever is greater). Many methods fail this criterion. The usual causes of failure are the presence of interfering compounds or the loss or destruction of the nutrient during extraction and sample preparation. Sometimes samples are contaminated from external sources and the resulting nutrient level is apparently higher than the true level. Some methods lack specificity, a particular problem when accurate analytical data are required for closely related molecular structures. Lastly, some methods lack the sensitivity to accurately measure nutritionally significant levels of a nutrient.

Precision is also an important consideration in the evaluation of a method. Common sense must be applied during the evaluation of analytical precision in nutrient analysis. The method must be sufficiently precise to yield credible nutrient composition information and at the same time some imprecision must be tolerated in the interest of time and economics. With pure standards, the maximum acceptable relative standard deviation (RSD) should range between 10 to 15%; attempts to obtain RSD's of 1% or less are probably impractical uses of resources. In the case of nutrient analysis in foods, acceptable precision should be tempered by the level of the nutrient relative to its nutritional significance. Stewart (1981a) has recently shown that RSD's in the range of 10-15% are adequate for all nutrients except for those that occur at low levels (5-30% RDA per serving) relative to their nutritional significance. In these cases precision criteria should be relaxed by some predetermined standard.

Analysis of identical samples by several laboratories often show unacceptably large variations among laboratories when different methods are used or even when the same method is used. Interlaboratory quality control of nutrient analysis must be improved because most nutrient composition tables and data bases are compiled from data generated by many laboratories. The appropriate use of quality control samples and the development and use of nutrient standards and standard reference materials will greatly improve the quality of nutrient composition data.

Modifications required to improve existing nutrient analysis methods are tabulated in Table 2 (footnote b). Changes to move a method from the substantial to adequate category may require only minor modifications of the extraction and quantification steps and/or application of the method to more food groups by the research community. Changes, however, required to recategorize an unacceptable method (conflicting or lacking) as acceptable (adequate or substantial) may require extensive method modification or development, development of extraction and sample preparation procedures and application of the new method to several different food groups.

Development of analytical procedures.-Substantial advancements in analytical instrumentation have been introduced during the past decade. The application of analytical instrumentation, however, constitutes only part of a total analytical procedure. Stewart (1980) has outlined the components of an ideal analytical method for the analysis of nutrients in foods. These components consist of homogenization and subsampling, extraction, separation, detection and identification, calculation of results and report generation, application of standards, standard reference materials and control samples, and finally validation of results. The development of a reliable analytical procedure is complex but relatively straight forward if the problem is approached in a systematic manner.

Scientists at the Nutrient Composition Laboratory (Agricultural Research Service, USDA), located at Beltsville, have been actively working on the development of new and improved techniques for the analysis of nutrients in foods for a number of years. They have taken a systematic approach to methods development by evaluating each component of the ideal analytical method, as detailed by Stewart (1980). A partial listing of the results of this effort is tabulated in Table 3. A considerable effort has been expended on developing techniques that not only quantify the total amount of a nutrient but also separate and quantify the various forms of a nutrient in a food. For example, methods have been developed to determine the level of the various forms of vitamin B-6 in foods (Vanderslice et al., 1983). Data generated from such procedures can be used to calculate the total amount of a nutrient in a food. More importantly, these detailed procedures will allow the assessment of bioavailability for specific nutrients or vitamers from food sources and will permit nutritionists and medical scientists to investigate the influence of various forms of a vitamin on the health of human beings. A number of other procedures have been developed to similar states of sophistication, e.g., Li et al., 1982, Slover et al., 1983 (Table 3).

During the routine analysis of samples with any analytical technique, adequate standards and control samples must also be analyzed to provide a basis for the validation of the results from unknown samples (Stewart, 1980). Only after careful validation of results can data be published and collated with other data in data bases. Scientists at the Nutrient Composition Laboratory in collaboration with investigators at the Consumer Nutrition Division (Human Nutrition Information Service) have developed a code system to provide information about the quality of data in food tables and provisional nutrient tables. The system has been recently described and applied to data on the iron content of food (Exler, 1983); an example of the application of the system is shown in Table 4. Briefly, the confidence codes of the data give the user of the data an indication of the confidence he can have in the mean value given in the table. The codes are based on a critical evaluation of the data sets from which the mean values were derived as outlined by Exler (1983). The application of confidence codes to nutrient data provides the users of these data, for the first time, an estimate of the reliability they can place in the data. The code system, as proposed, is not intended to be a "final" system, rather an initial system that can be altered and modified to provide the desired information to the users.

Procedures for the analysis of nutrients in foods are also often developed by scientists associated with other government laboratories, industrial laboratories or academic institutions. These procedures, like the procedures developed by scientists at the Nutrient Composition Laboratory, are published in journals of scientific organizations. Periodically, the state of new procedures are reviewed and published as an article in a journal, e.g., Gregory, 1983, or as a book, e.g., Charalambous, 1984. All of the above forms of documentation aid greatly in the transfer of new technology from the laboratory where it is developed to laboratories where it can be applied to a multitude of samples.

Development of methods for the accumulation of valid data on nutrients in foods continues to be a major research effort of the scientists at the Nutrient Composition Laboratory. A partial listing of methods that are currently undergoing development appears in Table 3. Current analytical methods for several of the nutrients listed in Table 3, i.e. carotenes, heme/non-heme iron, are primitive, non-existant, or non-specific, and as a result, a dearth of data exists. However, the importance of some of these nutrients to human health, i.e. carotenes, fiber, inorganics, has recently been emphasized by a report from a committee of the National Research Council (1982). Mathematically sound procedures for sampling the food supply of the United States are also being developed at the Nutrient Composition Laboratory. Application of these procedures will allow scientists to accurately estimate the variability in the nutrient content of foods across this country. Other important areas for which methods are being developed include validation of analytical data, automated sample extraction, and laboratory data management.

Development of instrumentation.-Development of new or improve analytical procedures for nutrient analysis of foods generally takes advantage of existing analytical instrumentation. During the past decade however, certain characteristics of the analysis of nutrients in foods, i.e., complex matrices, large numbers of nutrients of interest in a large number of samples and economics, have provided the impetus for the development of new analytical instrumentation. Two examples are the development of the concepts and equipment for 1) flow injection analysis, and 2) simultaneous multielement atomic absorption spectrometry.

Flow injection analysis (FIA), recently reviewed by Stewart (1981b, 1983), was developed simultaneously by a group of scientists in Denmark and by an independent group in the United States located at Nutrient Composition Laboratory. The U.S. group developed FIA to analyze a large number of samples during a relatively short period of time with high precision and accuracy. As the theoretical basis of FIA is evaluated and established (Vanderslice et al., 1981b), the applications of this new instrumentation appear to be very broad.

Simultaneous multielement atomic absorption spectrometry (SIMAAC), invented as a result of the cooperative efforts of scientists at the Nutrient Composition Laboratory and the University of Maryland, and recently reviewed by Harnly (1983) and Wolf and Harnly (1983), represents a combination of the advantages of atomic absorption spectrometry (AAS) and inductively coupled plasma, atomic emission spectrometry (ICP-AES) for the quantification of inorganic nutrients (minerals). The SIMAAC currently operating in the Nutrient Composition Laboratory is capable of quantifying sixteen elements simultaneously from either flame or furnace atomization, has extended analytical range capabilities, and is insensitive to interferences because background correction is determined for each element analyzed. Current research with SIMAAC is oriented toward development of furnace atomization as a more reliable atomization source and the development of a microprocessor controlled instrument.

SELECTION OF FOODS FOR NUTRIENT ANALYSIS

The summaries of the present state of knowledge of nutrient composition presented in Figures 2-9 show that a considerable amount of information on the nutrient content of many foods is inadequate or lacking. Nonetheless, in order to make advances in human nutrition, nutrient composition information for many food items must be generated as rapidly as possible, consistent with acceptable techniques of sampling and analysis. The numbers of foods available for sampling and analysis could overwhelm analytical resources unless nutrient composition studies are carefully planned.

An approach to the selection of foods for nutrient analysis, suggested by Stewart (1981a), is shown in Fig. 10. The square represents the large domain of all foods. Within the large domain, there are four smaller domains, represented by circles that correspond to: 1) core foods, 2) categories of foods which lack data (inadequate data), 3) foods having high concentrations of nutrient(s), and 4) foods as eaten. The overlap of the four smaller domains, represented by region 1 (Fig. 11), correspond to those foods for which it is appropriate to generate nutrient composition data immediately. Foods represented by the other regions have a lower priority for nutrient analysis, but it is hoped that all nutrients in all foods would ultimately be quantified.

Recent studies have demonstrated that a small percentage of the total food items available in the U.S. make up a large percentage of the total food consumed. About 15% of the available food items account for 90% of the weight of the diet consumed (Pennington, 1983) whereas about 4% of the total food items account for 90% of the reported frequency of consumption (Wolf, 1981). These foods with high consumption have been termed "core foods" (Stewart 1981a). The data in Table 5 compare the 15 highest ranking food items based on frequency of consumption and weight of consumption. There is remarkable similarity in the food items that appear in these two lists. Core food lists identified with specific socio-economic or cultural groups may vary somewhat from these lists. Nonetheless, a great deal of information on nutrient intake can be provided by using the nutrient composition of core foods.

The extent of the knowledge of the nutrient composition of food is presented in Figs. 2-9 and has been discussed earlier in this paper. Analysis of foods containing high concentrations of a nutrient(s) can be justified because foods that fall in this category as well as in the categories of foods as eaten and of core foods supply the majority of a nutrient in the diet. The analysis of low levels of nutrients in a food (<5% RDA per serving) may require extensive modification of analytical procedures in order to obtain adequate analytical accuracy and precision. In this case, a decision must be made in regards to the value of the analytical data relative to the cost of obtaining it.

Analysis of nutrients in "foods as eaten" provides the most accurate data on the nutrient composition of foods as consumed by human beings. These data will permit the total variability of the nutrient content of foods, influenced by such parameters as cultivar or breed, season, processing procedure, cooking method, etc., to be estimated. The use of limited distribution centers by many U.S. food suppliers, the widespread consumption of processed foods and the rigorous quality control systems used by the food industry have reduced the variability of the nutrient content in many foods. Several laboratories are currently collecting data and will soon be able to estimate the variability of the nutrient content in selected foods from nationwide samplings.

Scientists at the Nutrient Composition Laboratory have conducted a number of food sampling/nutrient analysis studies. Studies that have been completed, studies in progress and studies planned for the near future are tabulated in Table 6. In addition to the food item sampled, the nutrients that were analyzed or are planned for analysis, and the distribution of the nutrient data are also indicated (Table 6). It should be noted that all nutrient data generated from food sampling studies are made available to the Consumer Nutrition Division, the Nutrient Coding Center (National Institutes of Health, Minneapolis) and several other government agencies and laboratories for inclusion in their nutrient data bases.

Many of the programs currently ongoing at the Nutrient Composition Laboratory are cooperative efforts with other government agencies and state universities. For example, the Heart, Lung and Blood Institute (NIH, HHS) and more recently, the National Cancer Institute (NIH, HHS) support several of the programs related to the development of new and improved techniques for the analysis of nutrients in foods. Several food sampling/nutrient analysis studies have involved the cooperative efforts of scientists at the

Meat Science Research Laboratory (Agricultural Research Service, USDA), Consumer Nutrition Division and several state universities (pork, beef, and chicken). Results from these cooperative efforts have contributed greatly to the nutrient data that have become available in recent years.

Many federal, state and industrial organizations support studies that result in data on the nutrient content of foods. The Consumer Research Division currently has several active contracts that will generate considerable nutrient data. Heart, Blood and Lung Institute, National Cancer Institute, and Food and Drug Administration, through the Market Basket Survey, all have active research programs that will also result in nutrient data. Substantial amounts of nutrient data are generated by food processors and the food industry. Finally, data from many research programs at state and private universities are also integrated into nutrient data bases. Continued substantial support by a number of federal, state and industrial organizations will be required to provide complete and accurate data bases on the nutrient content of foods.

SUMMARY

Generating nutrient data is a complex process requiring decisions at several steps. Nutrients selected for analysis should be associated with public health problems, lack adequate analytical data, and have accurate and precise analytical methods available. In the case of some nutrients, accurate and precise analytical procedures need to be developed before analysis of nutrients in foods can proceed. The analysis of nutrients in those foods for which data are sparse should concentrate on frequently consumed foods which have been prepared by customary procedures; those foods which contribute large amounts of nutrients should be the first priority. Compilation of accurate and precise nutrient data bases will permit health professionals to accurately assess nutrient intake and utilization and to improve human health through nutrition education and/or therapy.

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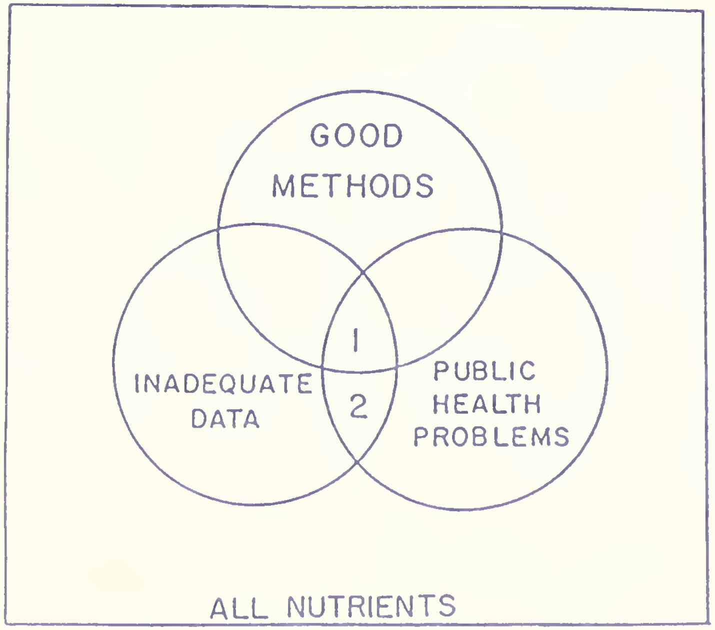

Figure 1. Schematic representation of factors used in the selection of nutrients for analysis. The square represents the domain of all nutrients. Each circle represents a smaller domain of nutrients associated with a specific factor. Region 1 represents those nutrients for which it is appropriate to generate composition data. Those nutrients represented by region 2 should receive high priority research on analytical methodology. Adapted from Stewart 1981a.

STATE OF KNOWLEDGE OF NUTRIENT COMPOSITION

CARBOHYDRATES

	INDIVIDUAL SUGARS	STARCH	NUTRIENT FIBER
BABY FOODS			□
BAKED PRODUCTS, BREAD		□	□
SWEET GOODS		□	□
COOKIES, CRACKERS		□	□
BEVERAGES	□	★	★
BREAKFAST CEREALS	●	□	●
CANDIES	□		
CEREAL GRAINS, WHOLE	□	□	□
FLOUR	□	□	□
PASTA	□	□	□
DAIRY PRODUCTS	●	★	★
EGGS & EGG PRODUCTS	★	★	★
FAST FOODS			□
FATS AND OILS	★	★	★
FISH & SHELLFISH, RAW	★	★	★
COOKED	★	★	★
FROZEN DINNERS			□
FRUITS, RAW	●		□
COOKED	□		□
FROZEN OR CANNED	□		□
INFANT FORMULA			
INSTITUTIONAL FOOD	□	□	□
LEGUMES, RAW	□	□	□
COOKED	□	□	□
PROCESSED	□	□	□
MEAT, BEEF	★	★	★
LAMB	★	★	★
PORK	★	★	★
SAUSAGE	★	★	★
VEAL	★	★	★
MIXED DISHES, COMMERCIAL			
HOME PREPARED			
NUTS & SEEDS	□	□	□
POULTRY	★	★	★
RESTAURANT FOOD	□	□	□
SNACK FOODS			
SOUPS			
VEGETABLES, RAW	□	●	□
COOKED	□	□	□
FROZEN	□	□	□
CANNED	□	□	□

(blank) LITTLE OR NO DATA □ INADEQUATE DATA ● SUBSTANTIAL DATA ★ NOT APPLICABLE

Figure 2. State of knowledge of the carbohydrate composition of foods.

STATE OF KNOWLEDGE OF NUTRIENT COMPOSITION

LIPIDS

	TOTAL FAT	FATTY ACIDS	CHOLESTEROL	OTHER STEROLS	TRANS-FATTY ACIDS
BABY FOODS	●	□			
BAKED PRODUCTS, BREAD	□	□			□
SWEET GOODS	□	□			□
COOKIES, CRACKERS	□	□			□
BEVERAGES			★	★	★
BREAKFAST CEREALS	●	□			
CANDIES	□	□	□	□	□
CEREAL GRAINS, WHOLE	□	●	★		★
FLOUR	□	●	★		★
PASTA	□	□	★		★
DAIRY PRODUCTS	●	●	●	★	★
EGGS & EGG PRODUCTS	●	●	●	★	★
FAST FOODS	●	□	□	□	□
FATS AND OILS	●	●	●	□	●
FISH & SHELLFISH, RAW	●	●	●	□	
COOKED	●	●	●		
FROZEN DINNERS	□	□			
FRUITS, RAW	●	□	★	□	★
COOKED			★		★
FROZEN OR CANNED	●		★		★
INFANT FORMULA	□	□			
INSTITUTIONAL FOOD	□	□	□	□	
LEGUMES, RAW	●	□	★	□	★
COOKED	●	□	★		★
PROCESSED	□	□	★		★
MEAT, BEEF	●	●	●	★	★
LAMB	●	●	●	★	★
PORK	●	●	●	★	★
SAUSAGE	●	●	●	★	★
VEAL	●	●	●	★	★
MIXED DISHES, COMMERCIAL	□	□	□	□	
HOME PREPARED	□	□	□		
NUTS & SEEDS	●	●	★	□	★
POULTRY	●	●	●	★	★
RESTAURANT FOOD					
SNACK FOODS		□			□
SOUPS	●	□	□	□	
VEGETABLES, RAW	□	□	★	□	★
COOKED			★		★
FROZEN	●		★		★
CANNED	●		★		★

(blank) LITTLE OR NO DATA □ INADEQUATE DATA ● SUBSTANTIAL DATA ★ NOT APPLICABLE

Figure 3. State of knowledge of the lipid composition of foods.

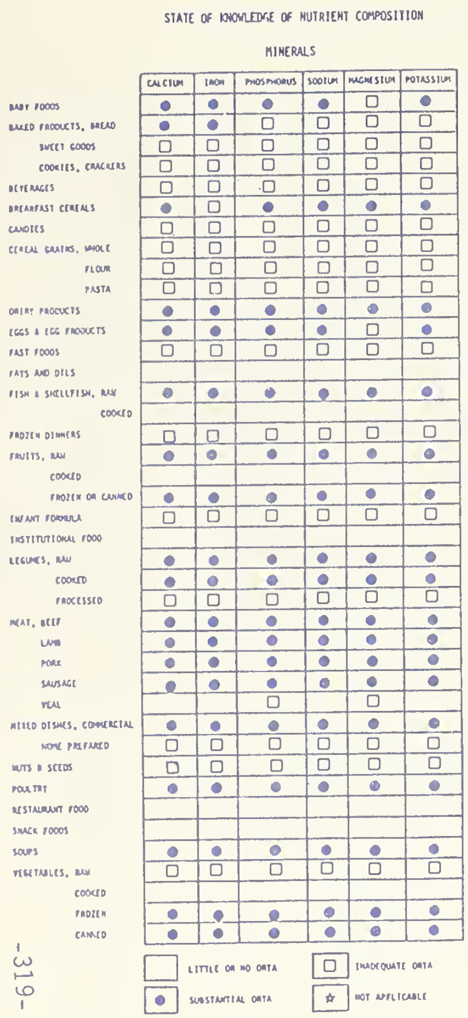

Figure 4. State of knowledge of the mineral composition of foods.

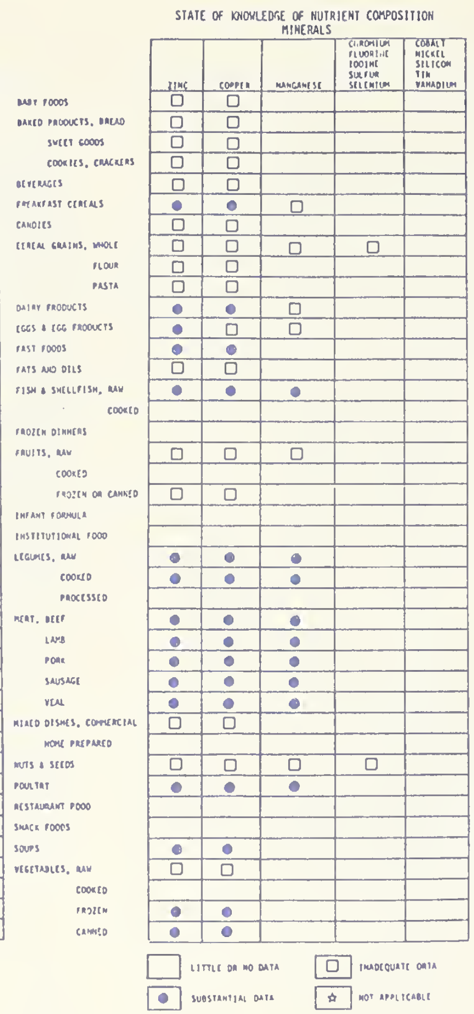

Figure 5. State of knowledge of the mineral composition of foods, continued.

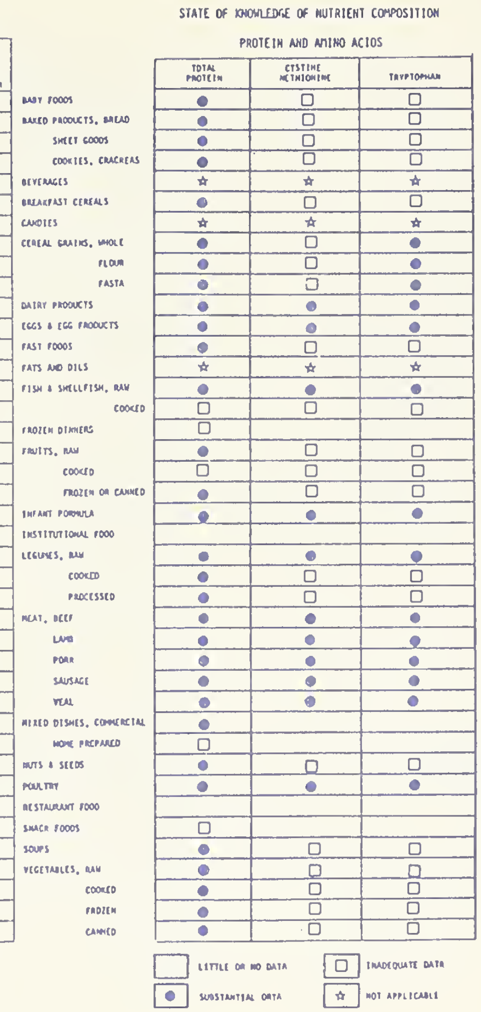

Figure 6. State of knowledge of the protein and amino acid content of foods.

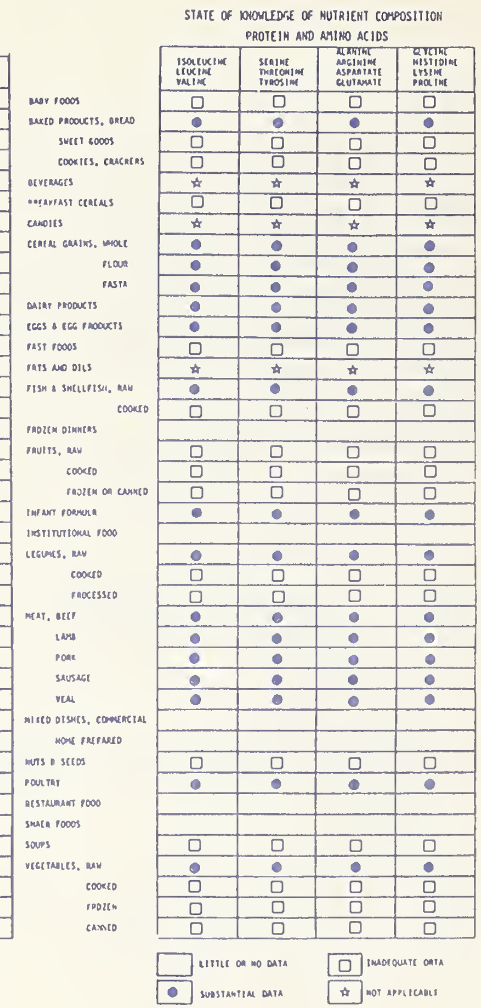

Figure 7. State of knowledge of the protein and amino acid content of foods, continued.

STATE OF KNOWLEDGE OF NUTRIENT COMPOSITION

VITAMINS

	Vitamin A	Vitamin B_1 Thiamin	Vitamin B_2 Riboflavin	Vitamin B_6	Vitamin B_{12}	Vitamin C Ascorbic Acid	Niacin
Baby foods	●	●	●	□	□	●	●
Baked products, bread	★	●	●	□	★	★	●
Sweet goods		□	□	□		★	□
Cookies, crackers		□	□	□		★	□
Beverages	□	□	□	□	★	□	□
Breakfast cereals	□	□	□	□	□	□	□
Candies	★	□	□	□	★	□	□
Cereal grains, whole	□	□	□	□	★	□	□
Flour	★	□	□	□	★	★	□
Pasta	★	□	□	□	★	★	□
Dairy products	●	●	●	●	●	●	●
Eggs & egg products	□	●	●	●	●	★	●
Fast foods	●	●	●	□	□	□	●
Fats and oils		★	★	★	★	★	★
Fish & shellfish, raw	□	□	□	□	□	★	□
Cooked							
Frozen dinners	□	●	●			□	●
Fruits, raw	●	●	●	●	★	●	●
Cooked	□	□	□	□	★	□	□
Frozen or canned	●	●	●	□	★	●	●
Infant formula							
Institutional food							
Legumes, raw		●	●	□	★	★	●
Cooked		●	●	□	★	★	●
Processed	□	□	□		★	□	□
Meat, beef	●	●	●	●	●	★	●
Lamb	□	●	●	●	●	★	●
Pork	□	●	●	●	●	★	●
Sausage	□	●	●	●	●	●	●
Veal	□	●	●	●	●	★	●
Mixed dishes, commercial	□	●	●	□	□	□	●
Home prepared	□	□	□				□
Nuts & seeds	□	□	□	□	★	□	□
Poultry	□	●	●	□	□	★	●
Restaurant food							
Snack foods							
Soups	●	●	●	□	□	●	●
Vegetables, raw	●	●	●	□	★	●	●
Cooked	□	□	□	□	★	□	□
Frozen	●	●	●		★	●	●
Canned	●	●	●		★	●	●

(blank) Little or no data □ Inadequate data

● Substantial data ★ Not applicable

Figure 8. State of knowledge of the vitamin content of foods.

STATE OF KNOWLEDGE OF NUTRIENT COMPOSITION

VITAMINS

	Folacin	Vitamin D	Vitamin E	Biotin	Choline	Pantothenic Acid
Baby foods	□	★	□			
Baked products, bread	□	★	□			□
Sweet goods	□	★	□			
Cookies, crackers	□	★	□			
Beverages	□	★	★	★	★	□
Breakfast cereals	□		□			□
Candies	□	★				□
Cereal grains, whole	□	★	□		●	□
Flour	□	★	□		□	□
Pasta	□	★				
Dairy products	□	●	□		□	●
Eggs & egg products	□	□	□		●	●
Fast foods			□			
Fats and oils	★	□	□	★	★	★
Fish & shellfish, raw		□	□		□	□
Cooked		□	□			
Frozen dinners		★				
Fruits, raw	□	★			□	□
Cooked	□	★				□
Frozen or canned	□	★				□
Infant formula						
Institutional food			□			
Legumes, raw	□	★	●		□	□
Cooked	□	★	□			□
Processed		★	□			
Meat, beef	●	□	□		□	□
Lamb	●	□	□			□
Pork	□	□	□		□	□
Sausage	□	□				□
Veal	●	□	□			□
Mixed dishes, commercial	□		□			
Home prepared						
Nuts & seeds	□	★	□	□	□	□
Poultry	□	□	□		□	□
Restaurant food						
Snack foods						
Soups		★				
Vegetables, raw	□	★	□		□	
Cooked	□	★	□			
Frozen	□	★				□
Canned	□	★				□

(blank) Little or no data □ Inadequate data

● Substantial data ★ Not applicable

Figure 9. State of knowledge of the vitamin content of foods, continued.

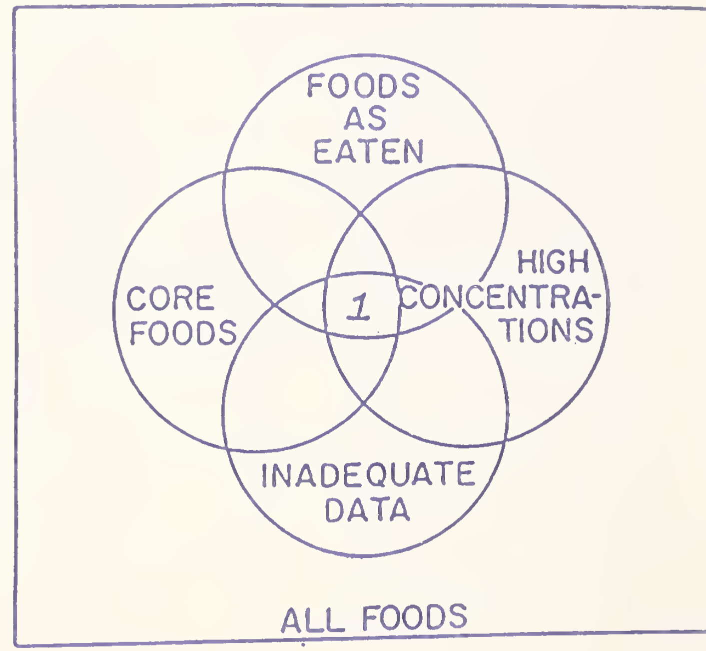

Figure 10. Schematic representation of factors used in the selection of foods for nutrient analysis. The square represents the domain of all foods. Each circle represents a smaller domain of foods associated with each factor indicated. Region 1 represents those foods that should be sampled for nutrient analysis. Adapted from Stewart, 1981a.

Table 1. CONTRIBUTION OF INADEQUATE OR EXCESSIVE NUTRIENT INTAKES TO PUBLIC HEALTH PROBLEMS IN THE U.S.[a]

Nutrient Category	Contribution to U.S. Public Health Problems		
	None known	Suspected	Accepted
Carbohydrates, fiber and sugars	Starch Maltose	Fructose	Lactose Fiber Sucrose
Energy			Food energy
Lipids	---	Fatty acids Other sterols Trans-fatty acids	Cholesterol Total fat
Minerals/Inorganic Nutrients	Cobalt Nickel Vanadium Tin	Arsenic Chromium Copper Magnesium Manganese Molybdenum Selenium Silicon	Calcium Fluorine Iodine Iron Phosphorus Sodium Zinc
Proteins and amino acids	---	Amino acids[b] Total protein[b]	---
Vitamins	Biotin Choline Pantothenic acid	Carotenes Niacin Vitamin E Vitamin K	Folacin Riboflavin Thiamin Vitamin A Vitamin B_6 Vitamin B_{12} Vitamin C Vitamin D

[a] Adapted from Stewart (1981).

[b] It is unlikely that increased information on the nutrient composition of foods for these nutrients will significantly help in combating the public health problems associated with these nutrients.

Table 2. STATE OF DEVELOPMENT OF METHODS FOR ANALYIS OF NUTRIENTS IN FOODS[a]

Nutrient Category	State of methodology[b]			
	Adequate	Substantial	Conflicting	Lacking
Carbohydrates, fiber and sugars		Individual sugars	Fiber Starch	
Energy			Food energy	
Lipids		Cholesterol Fat (total) Fatty acids (common)	Sterols Fatty acids (isomeric)	
Minerals/Inorganic nutrients	Calcium Copper Magnesium Phosphorus Potassium Sodium Zinc	Iron (total) Selenium	Arsenic Chromium Fluorine Iodine Manganese	Cobalt Heme-iron Molybdenum Nonheme-iro[n] Silicon Tin Vanadium
Proteins and amino acids	Nitrogen (total)	Amino acids (most)	Amino acids (some) Protein (total)	
Vitamins		Niacin Riboflavin Thiamin Vitamin B-6	Vitamin A Carotenes Vitamin B-12 Vitamin C Vitamin D Vitamin E Folacin Pantothenic acid	Biotin Choline Vitamin K

[a] Adapted from Stewart (1981).

[b] Description of methodology states

Factors	Adequate	Substantial	Conflicting	Lacking
Accuracy	Excellent	Good	Fair	Poor
Speed of analysis	Fast	Moderate	Slow	Slow
Cost per analysis	Modest (<$100)	Modest to high	High	?
Developmeno needs	—	Method modif. Extraction proc. Applications	Method develop. modif. Extraction proc. Applications	Method develop. Extraction proc. Applications

Table 3. ANALYTICAL TECHNIQUES DEVELOPED OR UNDERGOING DEVELOPMENT AT THE NUTRIENT COMPOSITION LABORATORY

Techniques Developed	
Fatty acids	Lanza et al., 1980
Fiber	Baker et al., 1979, 1983
Inorganics	Wolf 1979, 1982
Sugars	Li et al., 1982
Vitamin B-6	Vanderslice et al., 1983
Vitamin E and sterols	Slover et al., 1983

Techniques Undergoing Development

Carotenes
Fiber and fiber fractions
Heme/non-heme iron
Inorganics
Lipids and lipid components
Starch
Thiamin
Vitamin C

Automated sample extraction
Computerized laboratory data management
Nationwide sampling of foods
Reference materials/quality control samples

Table 4. APPLICATION OF CONFIDENCE CODES TO NUTRIENT DATA

IRON CONTENT OF EDIBLE PORTION OF FOOD

Item No.	Food	Amount of iron in 100 grams: Mean	Standard error	Number of samples	Confidence code[1]	AH-8 Item No. (1963)
		milligrams				
	BAKERY PRODUCTS					
	Breads:					
1	Cracked wheat	2.6	0.42	4	b**	444
2	French, enriched	2.8	.12	38	a	446
3	Mixed grain	3.2	.09	136	a**	---
4	Raisin	2.9	.29	11	b	452
	Rye:					
5	Pumpernickel	2.9	.19	4	b	456
6	Regular	2.7	.10	43	b	454
7	Wheat	3.5	.05	140	b	---
8	White, enriched	3.0	.02	445	a	461
9	Whole wheat	3.2	.15	27	a	471
10	Danish pastry	1.8	.10	9	b	1899
11	English muffins, plain	2.8	.09	25	a**	---
	Rolls:					
12	Dinner, enriched	3.1	.07	110	a	1902
13	Frankfurter or hamburger, enriched	3.0	.03	250	a	1902
14	Rye	2.8	( )	2	b	---
15	Tortillas, corn	1.9	.06	6	c*	---
	BEEF					
16	Hamburger, lean, cooked	2.7	.16	4	b*	368
17	Lean meat, cooked	2.7	.08	79	b*	---
18	Liver, fried	5.7	1.2	5	b*	1267

[1] Description of confidence codes; adapted from Exler, 1983.

Confidence Code	Meaning of confidence code
a	The user can have confidence in the mean value.
b	The user can have some confidence in the mean value; however, some questions have been raised about the value or the way it was obtained.
c	There have been some serious questions raised about this value. It should be considered only as a best estimate of the level of this nutrient in this food.
No asterisk	Data from two or more sources; mean of each source varies less than 30% from overall mean.
*	Data from a single source.
**	Data from two or more sources; mean of each source varies more than 30% from overall mean.

Table 5. COMPARISON OF CORE FOOD LISTS BASED ON

FREQUENCY AND WEIGHT OF CONSUMPTION

Rank	Food item based on frequency of consumption[a]	Food item based on weight of consumption[b]
1	Water	Water
2	Bread, white	Coffee
3	Milk, cow, whole	Milk, cow, whole
4	Coffee	Soda, carbonated, cola type
5	Orange juice, frozen, reconstituted	Tea
6	Tomatoes, fresh	Beer
7	Lettuce, raw	Milk, cow, 2% fat
8	Margarine	Soda, carbonated, lemon-lime type
9	Sugar, beet and cane	Orange juice, frozen, reconstituted
10	Soda, carbonated, fruit flavored	Bread, white
11	Butter	Soft drinks, from powder
12	Tea	Beef, ground, regular
13	Milk, cow, skim	Beef, steak, loin/sirloin
14	Soda, carbonated, cola type	French fries, frozen, heated
15	Jellies	Lettuce, raw

[a] Adapted from Wolf (1981); frequency of consumption based on a 14-day dietary record maintained by 22 subjects aged 14 to 64.

[b] Adapted from Pennington (1983); weight of consumption calculated as average grams per day for both male and female of the 14-16, 25-30 and 60-65 year age groups.

Table 6. FOOD SAMPLING NUTRIENT ANALYSIS STUDIES:

NUTRIENT COMPOSITION LABORATORY

Food or Food Group	Nutrient(s)	Distribution of Results
Completed studies		
Cereals	Fiber Inorganics Sugars Vitamin B-6	Baker and Holden, 1981 Nutrient data bases Li and Schuhmann, 1980, 1981 Vanderslice et al., 1981a
Fruit and Vegetable juices	Inorganics Sugars	Nutrient data bases Li and Schuhmann, 1982
Yogurts	Inorganics Sugars	Nutrient data bases Li et al., 1983
Fast foods	Lipids	Slover et al., 1980
Bacon	Inorganics	Nutrient data bases
Cured pork	Inorganics	Nutrient data bases
Core foods (limited)	Inorganics	Nutrient data bases
Studies in progress		
Pork	Several	
Beef	Several	
Ground beef	Several	
Chicken (supermarket)	Inorganics Vitamin B-6	
Tuna	Inorganics Vitamin B-6	
Salty snack foods	Several	
Planned studies		
Chicken (Fast food)	Several	
Ground beef	Se	
White bread	Se	