A COMPUTERIZED SYSTEM FOR INSTRUCTION IN FOOD SELECTION PRACTICE

by

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ABSTRACT

This thesis has developed a prototypical system which provides information on dietary practices for those individuals interested in applying nutritional principles to their eating habits. The system has the potention to provide information which both accurately reflects nutritional guidelines and facilitates adoption of recommendations, by providing a self-explanatory statement of foods to consume and by limiting suggested changes in present food pattern.

The prototypical computerized system developed has two major functions: (i), diet-assessment to appraise the acceptability of individual's dietary practices; and (ii), diet-planning to recommend modifications in the diets of those individuals not meeting specified limits. The focus of the system is a constrained-optimization algorithm that generates a revised food plan which both satisfies nutrient constraints, and minimizes the deviation of food items and item groups from the original amount consumed by the client.

Testing has been restricted to a descriptive evaluation of some of the algorithm's characteristics -- specifically, the design assumptions which define the acceptability of deviating from an original inventory, and the revised diets developed when these assumptions are modified. The results illustrate that altering these design assumptions produces marked variations in the revised diets with respect to observed parameters. Further modifications in the algorithm have been suggested.

The explorative evaluation provides a foundation for more systematic evaluation of the validity of the algorithm. Recommendations for facilitating the further development and testing of the system are outlined.

This thesis has shown that mathematical modeling provides an effective means of collating the vast amount of data required to develop cogent dietary recommendations which are nutritionally accurate, straightforward, and acceptable to the client.

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CHAPTER 1

INTRODUCTION

1.1 Background and Need for the Study

1.1.1 Fundamental Tasks of Nutrition Education Programs

Nutrition education, as a process to promote the public welfare, is universally needed to ensure healthful food selection. Since "there is no instinct that guides man to select those foods which meet the nutritional needs of the body ... each new generation must be taught what foods to select ..." (Todhunter 1969, p. 9). Furthermore, it is needed because societal forces, which influence food availability, must parallel knowledge of nutritional well-being to ensure that appropriate products will be available for selection.

The American Dietetic Association (1973), in its "Position Paper on Nutrition Education for the Public", defines nutrition education as "... the process by which beliefs, attitudes, environmental influences, and understandings about food lead to practices that are scientifically sound, practical, and consistent with individual needs and available food resources" (p. 429).

As the above definition implies, the fundamental tasks of nutrition education personnel are two-fold. First, nutrition educators provide a code of nutritional practice through the judicious interpretation of scientific studies, and strive to reduce the time lag between the discovery of nutrition knowledge and its application to food practice (Gifft et al. 1972; Leverton 1974). Second, nutrition educators communicate available knowledge to the public sector with awareness of the variety of audiences - individual citizen, "activated" consumer, governmental bodies, and industry - that may be approached to ultimately effect changes in food practices by their influence on either available food supply or food selection behaviours (American Dietetic Association 1973; Leverton 1974). Also, in communicating with the public sector, the nutrition educator must be aware of the complex dynamics of communication with target audiences that potentiate or deter change in food habits.

1.1.2 Criticisms of Nutrition Education Programs

Man's knowledge of food and its implication for well-being has evolved through the course of centuries. Traditional knowledge of food, previously based on "... a long series of trials and errors -- sometimes mortal errors -- ..." (Mayer 1973, p. xxi) has been greatly extended by the systematic investigation of the present day. The new scientific-technologic tradition has produced an explosion in knowledge of dietary consequences for health, and with this a growing suspicion that this knowledge is not being applied to its full potential.

In 1941 nutrition-related medical problems were shown to be affecting much of the potential American military manpower. In that year

> ...John R. Murlin, participating in a White House Conference on Nutrition and Defense, stated: "Knowledge is like a rock set upon a shelf. It does no harm, and it does no good, so long as it rests there, but let somebody jar the shelf and let the rock fall off, and then something happens. That is the state of things today. We know more than we are doing." (Hill 1969, p. 14)

Similar sentiments have been echoed to the present day. Briggs (1969) suggests that "advances in nutrition-related research are only useful when extensively applied ... but the link between this knowledge and its application is extremely weak" (p. 8). Concerning the state of knowledge in the science of nutrition, White (1976) states that "obviously much more is known about nutrition and human needs than is manifest by the current practices of our population" (p. 54).

Current criticisms on the gap between nutritional knowledge and its apparent application, stem from western population studies (U. S. Department of Agriculture 1968; U. S. Department of Health, Education, and Welfare 1972; Canada 1973) identifying significant incidences of nutrition-related problems, and in some, a trend for decline in dietary quality as compared to previous decades. Also, there have been great increases in mortality from diseases with dietary involvement, which appear to be largely preventable. While health and medical expenditures have continued to rise, no strong evidence exists to indicate that any corresponding benefits have occurred in the major health indices. For example in the United States, life expectancy of those over twenty has not improved in the last twenty-five years, a period when expenditures have increased eightfold (Cornely 1974). Mayer (1975) aptly comments, "like Alice in Wonderland, we are running faster and faster to stay in the same place" (p. 11).

Briggs (1969) suggests that "... we do have sufficient scientific knowledge to conduct sound programs of nutrition education ... " (p. 8). If so, then what are the reasons for the discrepancy between this knowledge and population food practices? The reasons for this discrepancy may be categorized in two primary areas which coincide with nutrition education's aforementioned responsibilities, namely, the problem of developing a scientific-nutritional code, and the complexity of translating this code to the public sector.

1.1.2.1 Developing a Scientific - Nutritional Code

As indicated in "A New Perspective on the Health of Canadians" (Lalonde 1974):

> The spirit of enquiry and skepticism, and particularly the Scientific Method, so essential to research, are, however, a problem in health promotion. The reason for this is that science is full of "ifs", "buts", and maybes" while messages designed to influence the public must be loud, clear and unequivocal (p. 57).

Indeed, uncertainty in scientific circles is often reflected in ambiguous statements to the public on which course of action to follow. As Mayer (1975) indicates, "we have been telling people what they should eat but avoiding strong statements about what they ought not to eat or to eat less of. We 'stay away from controversial subjects' ..." (p. 8). Unresolved scientific issues would not matter provided they stayed in academic circles. However, the environment in which sound nutrition practices are promoted is competitive and often hostile. Misinformation, often with a seed in scientific debate, is part of this environment -- a fact which vacillation on issues by the scientific community does nothing to alleviate. In fact, vacillation may ultimately breed distrust, by a significant proportion of the public, in science and technology generally, and specifically in the quality of the food supply and in the potential of nutritionists to reflect meaningfully on these issues (Leverton 1974).

When information becomes public knowledge, regardless of whether scientists believe the evidence is sufficient for a conclusion, the public begins to act through the voices and opinions of media. Mayer (1972) recommends "given this situation, it is better to act on the conjecture of scientists than on the guesses of newspapermen" (p. 240). Otherwise, "as the nutritionally trained people contemplate their disagreements on approaches to nutrition, many persons not trained in nutrition are making decisions on what foods are available in stores and in what form" (Ullrich 1973a, p. 184).

As the complexity and scope of nutrition knowledge increases, and therefore the task of interpretation appears more difficult, it becomes particularly important that comprehensive and coherent recommendations on dietary practices be provided. The failure of nutrition education to meet fully its obligations to provide a code of appropriate practice is suggested by criticisms (Robinson 1976) indicating the absence of clear recommendations for action on controversial aspects of diet, and on newer findings in dietary relationships for health.

1.1.2.2 Communicating a Nutritional Code to the Public

The ultimate recipient of nutrition information is the public and it is their dietary well-being which indicate the success of nutrition education activities. The delivery of nutrition information to the public is not the exclusive domain of the nutrition educator, nor is the medium of exchange restricted to "bookish ministrations". In order to effectively communicate nutrition information "nutrition and health educators must be concerned with human behaviour and therefore must compete with all internal and external forces that define and control how an individual behaves" (White 1976, p. 54). Criticisms, discussed below, suggest that nutrition educational programs have failed to keep pace with the changing communication mileau of nutrition information in western societies, both in terms of the variety of audiences that must be approached to ultimately influence the dietary practices of the public, and also the complex dynamics of communication with the public in an informationally-competitive society.

1.1.2.2.1 Communication with a Variety of Audiences

Food habits of individuals are determined by a number of factors including the foods available in the marketplace, and information disseminated in the media -- both factors which have been influenced massively by food technologists, manufacturers, advertisers, and legislators. Thus, in addition to communicating a nutritional code directly to the public through schools, hospitals, and media, nutrition educators must recognize audiences in both industry and government through which the public is influenced, and through which nutrition information can indirectly reach the public (Anon 1972). For example, dietary lifestyle can be influenced through food processing and manufacturing regulations, media policies and advertising guidelines.

As Ullrich (1974a) indicates, "objective nutrition education should not be the exclusive responsibility of any one group but a balance among government agencies, food industry, and educational institutions" (p. 84). However, in efforts to promote sound nutrition, as Gussow (1972) observes, "... most professionals were much more worried about the excesses of the 'health food' stores than the excesses of what at least one observer has called the 'unhealth food stores' ..., [and] until very recently, this misplaced concern extended even to advertising" (p. 48 and 49). In attempts to combat misinformation, the colourful, but perhaps insignificant antics of the charlatan have attracted the greatest attention of nutritionists. For example, recent popular food movements, the "health foodists" as coined by Wolff (1973), may be allies and not enemies of nutrition education. Professional emphasis on such groups may have resulted in nutritionists ignoring other, perhaps more significant, forces which influence food habits and which may be important factors promoting misinformation. Further, Hall (1975) suggests that nutritional science is outmoded in its ability to deal with the modern world of nutrition. Nutritionists "... practice a science, outmoded by technological reality, [thus] they can not influence ... [the] political process" (Hall 1974 p. 9).

1.1.2.2.2 Complex Dynamics of Communication with the Public

Beyond the influence nutrition educators can have on the public's dietary practices via intermediary bodies, such as government and industry, the nutrition educator can affect public consumption patterns by directly providing information to individuals.

The food choices of individuals are determined by a complex of internal and external forces that define and control behaviour (Gifft et al. 1972). Among the external or environmental forces influencing food behaviour are the foods available, mass media, cultural tradition, and governmental policy. Thus, in providing information directly to individuals, consideration must be given to the many competing forces that influence food practices -- forces which define the complexity of the informational environment in which nutrition educators must function. With respect to two environmental influences -- foods available in the marketplace and diet-related discussions generated by mass media and advertising -- criticisms suggest that nutrition education programs have been inadequate competitors.

1.1.2.2.2.1 Changing Food Market

Food technology, industrial development, and rapid transportation have greatly increased the number, kinds, and availability of food products (Todhunter 1969). Whereas in 1928 the average supermarket contained around 900 items, large supermarkets now carry in excess of 10,000 items (Gussow 1972). Thus, "today, more than ever, there are more opportunities to make poor food choices because of the broad array of new foods available" (Anon 1972, p. 34). " ... The shopper has the difficult problem in properly selecting the best buys in both nutritional and monetary value" (Todhunter 1969, p. 9). As Ullrich (1975) states, "the technology of providing a large variety of foodstuffs in the marketplace has far outstripped the knowledge of the consumer to make wise choices" (p. 48).

The nature of the food supply has been virtually transformed as a result of technological development. "In 1941, only 10 percent of our foods were highly processed; today, that amount has risen to 50 percent" (Mayer 1972, p. 239). In addition to the alterations that processing may cause in nutrient characteristics and distribution of nutrients in foods, approximately 1,830 additives are available for routine use in foods (Hall 1973). Many of these substances are either new in the diet or are present in greater proportion than previously.

With the change in food supply has come a change in food habits as illustrated in the following statements by Ullrich (1974b):

> A look at the present state of our national food consumption compared with 25 or 50 years ago shows a decline in the consumption of foods of high nutrient quality in relation to consumption of foods of low nutrient quality. In part, the decline may be due to the over-zealous development and heavy advertising of "fabricated" food products that are not equal to the conventional foods they replace (p. 4).

There is concern in nutritional circles that consumption of products of low nutrient quality coupled with current patterns of low energy expenditure may lead to nutritional problems (Harper 1974). Mertz (1972) suggests that increased use of textured vegetable proteins and refined grains may result in depletion of trace elements. However, the Ten State Survey (U. S. Department of Health, Education, and Welfare (1972) indicates in its "Highlights", " ... inadequate information is available on the distribution of nutrients in today's food supply ... " (p. 12). The long term effect of fabricated diet consumption is not known. Additionally, the consequence of long term consumption of many additives and particularly of combinations of additives is not known.

To be effective, nutrition education programs must keep pace with the changing food supply, and with the consequent influence of food supply on behaviour and nutritional well-being. Regardless of the cause of the present transformation in foods available, or of the difficulty of interpreting the consequences of these changes, it is the responsibility of the nutrition education profession to provide rational and useful guidelines for the public, industry, and government -- guidelines that are relevant to the present type and variety of foods available.

1.1.2.2.2.2 Mass Media and Advertising

As Gussow (1972) points out, " ... between 1928 and 1968 people had learned to eat thousands of new food items" (p. 48). If people, as nutritionists say, have food habits which once established are difficult to change, then what change agent has been effective? Her implication is that advertising is a significant factor, and particularly advertising on television. Manoff (1973), who has also publicized the importance of media and advertising as a nutrition education (or miseducation) force, indicates that, "of the 6,000 to 8,000 items on sale in American food stores, 50 percent of them did not exist 20 years ago. This would not have been possible without commercial television, which began roughly

20 years ago" (p. 126). Presumably the Canadian situation is similar.

These factors are of particular significance to the nutritionist since the massive influence of advertising is motivated by marketing forces and not by a concern for nutritional value. As Manoff (1973) suggests, "food manufacturers produce anything they can sell at a profit. This is the elementary law of marketing" (p. 128). Although the food industry claims to act in the consumer's interest by supplying consumer demands, millions of dollars are spent each year on advertising to influence consumer purchase of foods having high profit, but often low nutritive value (Gussow 1972; Manoff 1973). Mayer (1975) further questions the motives of the food industry, stating, " ... the opposition to the proposed Consumer Protection Agency in [the United States] is being led by the large food companies. [He adds,] I leave you to draw your own conclusion on what this may represent" (p. 11). Manoff (1975), paraphrasing and quoting Mayer, suggests:

> ... the reasons that food manufacturers appear reluctant to concentrate on foods of higher nutritional value ... is that there is no insistent demand for such foods. "Until the American mentality changes", he said, "food manufacturers will feel no strong injunction to provide such products". (p. 139).

Although mass media are a significant force in molding population food practices, " ... the mass media has been virtually abandoned by nutrition educators to the commercial food marketer and his nutrition education ..." (Manoff 1973, p. 125).

If consumer mentality is to change, "legitimate" nutrition education, in addition to the traditional nutrition education vehicles of school, clinic, and hospital, must make effective use of media and advertising techniques to match the efforts of the food industry (Anon 1972; Manoff 1973; Manoff 1975). Additionally, the formidable force of advertising in molding present attitudes and practices, establishing relevant public nutrition issues, and influencing the nature of the food supply, must be recognized when establishing nutrition education programs.

1.1.3 Summary and Conclusions

Since the public is the ultimate user of nutritional information, it is the task of the nutrition education profession to provide the consumer with comprehensive food selection guidelines; and to influence which foods and information are available through activity in government, the food industry, educational services, and the marketplace. Nutrition education programs in western countries have been criticized for not keeping pace with the complex changes in food available in the marketplace, and the complex discussion within the community on dietary issues influencing health, whether of legitimate or artifactual origin.

If the above difficulties plague the nutrition education profession in its efforts to guide nutritional practice within society, then they also plague individual citizens when nutrition education programs are not effective. That is, when these programs cannot properly provide the necessary information to the public, the individual must become the sole arbiter of nutrition information. Thus, the individual has the confusing tasks of resolving the complex dietary issues; of interpreting the worth of conflicting recommendations and admonitions from nutritional, medical, media, and marketing sources; of coordinating food selection practice in the face of a vast number of dietary provisos; and of selecting items from an overwhelmingly complex food supply -- in short, an information overload. As stated by Mayer, and quoted by Ullrich (1973b), concerning the nutritional literacy of the American people: " ... we have a very tired mind subjected day in and day out to a tremendous amount of information which is mostly misinformation by people who have something to sell" (p. 224).

Programs providing nutrition education services directly to the public must consider the complex forces influencing food decisions of individuals and families -- forces which nutrition education can not presently buffer through means other than public education. Unfortunately, the tendency has been to believe that individuals cannot handle complex information on foods, and therefore will benefit more with simplified guidelines on food selection practice. In so doing, nutrition educators leave the consumer as prey to the whims of industry and advertising. Oversimplified nutrition information does not properly equip the consumer for the present world of nutrition information.

Although it is not necessary that each individual be a nutrition specialist, she or he should be offered the opportunity to confidently eat as one. It is the responsibility of the nutrition education profession to provide the consumer with the resources necessary to collate available information on foods and nutrition, so that rational choices can be made. This includes useful guidelines which are comprehensive in coverage of recognized and proposed dietary issues, and relevant to the present variety and types of food available in the marketplace. Proposals by leading authors in nutrition indicate a trend to more comprehensive and detailed information. For example, Mayer (1975) states, "in order to teach nutrition to a broader audience, we obviously have to embrace a much broader concept of nutrition than talking about nutrients and foods which existed 25 years ago" (p. 8).

1.2 Thesis Goal and Objectives

1.2.1 Thesis Goal

The overall goal of the thesis was to develop a prototypical system which provides information on dietary practices for individuals who:

(i) want to apply nutritional principles to their eating habits; and

(ii) have sufficient resources (eg. time, energy, education, money) to use the information which defines healthful dietary practices for them.

This development was undertaken bearing in mind:

(i) The complexity of developing a scientific-nutritional code due to the many unresolved dietary issues under investigations, and the consequent problem of translating available knowledge for health promotion at the community level.

(ii) The complex factors influencing communication with individuals which the nutrition educator must consider -- that is, an environment with an overwhelming array of foods to choose from, for an equally overwhelming number of reasons -- and the unsatisfactory resolution of this condition by individual exposure to contradictory information provided by media sources.

1.2.2 Thesis Objectives

1.2.2.1 The First Objective of the Thesis

The first objective, arising from the thesis goal, was to develop a prototypical computerized system with two major functions, namely:

(i) diet-assessment in order to appraise the dietary intake of individuals, and

(ii) diet-planning in order to recommend modifications in food intake for those individuals with diets which do not meet specified nutrient limits.

Specific characteristics of the system are defined in "System Design and Characteristics" (p.109).

1.2.2.2 The Second Objective of the Thesis

The second objective, arising from the thesis goal, was to test the diet-planning component of the prototypical system. This testing explored some of the conceptual assumptions of a model designed for modifying diets which do not meet specified nutrient limits. The results of this work is reported in "Testing of the Prototypical System" (p.128).

CHAPTER 2

REVIEW OF LITERATURE

2.1 Definition of an Adequate Diet

The criteria used for appraising diets are ultimately derived from a knowledge of the dynamics of these diets in human populations. Presently, the criteria for appraising diets of normal individuals are defined in the dietary standard (Passmore *et al.* 1974; United States 1974; Canada 1975) -- in a sense, a compendium of known nutrient requirements used in the evaluation and design of diets.

Any discussion about providing information on food selection practice should consider the theoretical foundation of the dietary standard, and more broadly, the basis for defining an adequate diet. Thus, this discussion begins with a cursory examination of the influence of diet on the human individual and on the society in which the individual lives.

2.2.1 Influences of Diet in Human Populations

2.1.1.1 Influences on the Individual

Diet has many influences on the human organism. Both human physiology and perception are influenced by diet's nutrient and non-nutrient constituents, and its characteristics conferred by human imagination and cultural beliefs.

With respect to nutrient constituents, more than forty are presently recognized as essential for normal body functions of growth, maintenance, and repair (United States 1975). Deficiencies of one or more of these nutrients results in a plethora of physiologic and psychologic symptomatology, touching all systems of the body (Goodhart and Shils 1973; Pike and Brown 1975). Similarly, overnutrition is also associated with disease symptomatology. For example, a nutritional component has been suggested for many of the degenerative diseases (Canada 1976a), and for such ubiquitous problems as dental disease (McBean and Speckmann 1974). In addition to nutrient involvement in the causation of disease, nutrients may alter physical and mental potentials within the vaguely defined limits of normal well-being. For example, a special athletic dietary regimen, called the glycogen loading diet, maximizes available energy for performance (Astrand and Rodahl 1970; Astrand 1973). As a further example, Davis and Williams (1976) suggest that diet may influence such factors as sleeping pattern and healing time.

Diet can also be a vehicle for an immense array of potentially harmful or beneficial non-nutritive substances. Toxic food substances are found in the environment naturally (United States 1973) -- for example, lathyrism and aflatoxin -- and as a biproduct of modern technology which has introduced many new chemicals into the environment and into foods (Hall 1973; Hall 1977; W. H. O. 1978). Beneficial non-nutritive substances found in food include the active anti-infective property called lactobifidus factor found in human milk (Jelliffe and Jelliffe 1971), and dietary fiber (Burkitt and Painter 1974; Klevay 1974; Spiller and Amen 1975). Further, food includes substances which provide taste, color, texture, smell, and other sensations. These influence the desirability of items for consumption, and the nature of the eating experience (Kinder 1973).

Diet in some cultures is believed to have properties beyond the physical. For example, the idea that the "heat" or flesh of a brave enemy or animal conferred courage has existed in cultures from as early as the

Stone Age (Lowenberg et al. 1974). Additionally, beliefs based on hygenic observations, and taboos not so empirically founded, exist in most cultures (Lowenberg et al. 1974). Even if these beliefs have no basis in fact, their influence may be sufficient to confer either benefits or detriments; in any case they have consequences for the population even if a physiological effect is absent.

2.1.1.2 Socio-Economic Influences of Diet

Diet has implications beyond its physiologic and psychologic influences on the individual, extending to those of a social, economic, and political nature. Authors who have addressed these issues include: Berg (1973), who examines the role of nutrition in national development; Correa (1975), who discusses the influence of nutrition on socio-economic development; and Mitchell (1975) with a consideration of the dynamics of food production and supply in context of Canadian economic policy.

2.1.2 Criteria of an Adequate Diet

As indicated, nutritive and non-nutritive elements of the diet have many influences on the individual and on the society in which the individual lives. Thus, to properly identify an optimal or ideal diet potentially requires consideration of this multitude of dietary agents and their consequences. In turn, to identify desirable consequences may require consideration of the objectives and aspirations of individuals and their society.

"A major objective of the Food and Nutrition Board of the NRC continues to be to encourage the development of food use practices by the population of the United States that will allow for maximum dividends in the maintenance and promotion of health" (United States 1974, p. 1); where "health is defined according to the World Health Organization, as 'a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity'" (United States 1974, p. 1).

However, even when collective recognition of the desirability of healthful food practices exists, as exemplified by the objectives of a recognized body such as the Food and Nurtition Board, defining the optimal diet may still be difficult -- quite apart from the problems of defining health alone. For example, it may be that not all apparently desirable dietary practices are mutually compatible. "It is not at all certain ... that the nutritional requirements for maximum size, early maturity, active sex life, and maximum muscular development are identical with those for maximum longevity" (Goodhart 1973, p 403), resistance to chronic diseases, and maximum physical and mental performance in old age (Harper 1974). Furthermore, "diets designed to protect the individual against bacterial infections, such as Tuberculosis, may lower resistance to certain viral infections and predispose the individual to obesity and coronary heart disease in later years" (Goodhart 1973, p.403). Thus, as Goodhart (1973) summarizes, " ... statements such as 'An adequate diet is one which meets in full all the nutritional needs of the person have little meaning unless they can be interpreted in terms of either the person's ambitions for himself or the community's designs for or on him" (p.403).

Another factor that may make definition of the ideal diet difficult is conflict between dietary objectives and other objectives of an individual or a society. For example, bottle feeding of infants is becoming socially fashionable in third world societies, but economic and technologic constraints often make this practice nutritionally unsound (Jelliffe 1973).

However, increased well-being may conceivably result in some instances when apparently less than ideal diets are used in favour of meeting other personal or social priorities, as for example, that moderate alcohol consumption increases well-being, with respect to coronary risk (Yano et al. 1977).

In summary, the optimal diet -- the best dietary option described by environmental, biological, societal and personal circumstances -- is the diet which most effectively contributes to the achievement of the goals and aspirations of the society and of the individuals in the society. Its definition involves, in addition to identification of the many relevant consequences diet has for societal and individual realization, choosing among a variety of apparently equivalent but mutually incompatible dietary objectives, which in turn conflict with other personal and societal aspirations.

2.1.3 Nutrient Requirements

Although complex criteria, such as those discussed above, are relevant for defining an optimal diet, at present a more modest formulation of desirable dietary practices has been defined. This is the "adequate diet", as described by Goodhart (1973), which is based on human metabolic requirements for essential nutrients.

Nutrient dynamics in the body can be envisioned as a contiuum from the extremes of depletion to repletion, presumably with a circumscribed optimum between (Arroyave 1971). Ideally, to monitor these changes, criteria are required which differentiate the metabolic continuum from these extremes, and which identify the optimum for an individual in any particular situation for any nutrient. In the absence of suitable methods and criteria to identify a "nutrient optimum", the establishment of a requirement for a nutrient, defined by the Food and Nutrition Board (United States 1974) as " ... the minimum intake that will maintain normal function and health" (p. 8), " ... rests on the production of a deficiency[0] and on the definition of that daily intake which prevents or cures the deficiency state" (Mertz 1972, p .19). Criteria to determine these requirements are based on sensitive measures of biological response to nutrient depletion, such as, gross clinical symptomatology, and metabolic, biochemical, or other biophysical-functional changes (Arroyave 1971).

The known nutrient requirements are largely outlined in the dietary standards of various countries and international agencies, such as: the "Dietary Standards for Canada" (Canada 1975), the "Recommended Dietary Allowances" (United States 1974) in America, and the "Handbook on Human Nutritional Requirements" (Passmore et al. 1974) by the World Health Organization. The dietary standards, will be discussed more fully in "Data Evaluation" (p. 62). As discussed later (p. 74), other dietary goals beyond those presented in the dietary standard have been proposed.

0. Deficiency is defined as "...an habitual intake by the individual below his own true requirement. The manifestations of such 'deficiency' will depend upon the criteria by which the requirement has been defined ..." (Beaton 1972, p.357).

2.2 Relevant Systems

2.2.1 Food Guides

Although there are many different approaches to teaching nutrition (Ahlstromand Rasanen 1973), food guides have been the standard model for outlining the adequate diet in nutrition education (Chandler and Perloff 1975; Winarski 1976). Examples of food guides include: Canada's Food Guide (Canada 1977) the Basic Four and Basic Seven (U. S. D. A. 1976, U. S. D. A. 1971), and the Type A Pattern for school lunches (Head et al. 1973). Food exchange lists (Caso 1950)are examples of guides developed for use in planning therapeutic diets.

The food guide is intended as a simple and reliable nutrition education device for teaching the principles of healthful food selection. The food guide is a translation of nutrient requirements into a guideline of suggested serving of items from a few basic groups of foods with roughly equivalent nutrient composition (Ahlstrom and Rasanen 1973; Hertzler and Anderson 1974). Foods are classified into basic groups according to both their major nutrient contributions to the diet, and other criteria which assure the guides' applicability for the population and its utility as a teaching tool. These other criteria include: the food's function in the meal system of the population; foods available; educational status, income, and lifestyle of the population; and local nutritional needs. (Hayes et al. 1955; Lachance 1972; Ahlstrom and Rasanen 1973; Hertzler and Anderson 1974; United States 1974).

The problem in the design of food guides is to strike the balance between simplicity -- so that the information can be understood and remembered -- and validity -- so that the guide accurately reflects the dietary standards. To this end adaptations and modifications have been made to meet the needs of different populations and for different purposes, but the basic model of a limited number of natural food groups has remained (Hertzler and Anderson 1974).

Even though the utility of the food guide is recognized, it has been criticized as a teaching tool for a number of reasons, including: its falliblity in guiding proper food selection practices; its inapplicability to the present food supply; its lack of relevance for contemporary nutrition problems of the propulation; and its ineffectiveness as a teaching tool in an informationally-competitive society. Each of these criticisms will be dealt with below.

2.2.1.1 Fallibility in Guiding Food Selection Practices

The validity of the simple plan, based on four or five groups, which is used in the United States and Canada for directing food selection practice has been questioned (Anon 1972). Even for populations whose preferred style of eating is reflected by the food guide, it is recognized that the guide is fallible. For example, it is known that the food guide system can be invalidated by consistently making poorer choices in a food group, skimping on serving sizes, or using improper cooking and preparation practices (Bogert et al. 1973). Also, the required allowance of nutrients can be obtained from a wide variety of food combinations and patterns, besides those of the food guide (United States 1974).

A simplified eating plan, as in the food guide, is based on two basic assumptions: first, only a few key nutrients need to be monitored out of forty-plus possible known and unknown nutrients; and second, the nutrients not being monitored inevitably occur in the variety of foods selected for the key or index nutrient (Bogert et al. 1973). To test these assumptions Pennington (1976) evaluated two diets selected by Page and Phipart (1957) in accordance with the "Basic Four" plan, against the 1973 Recommended Dietary Allowances of the Food and Nutrition Board (United States 1974). Although the four index nutrients (protein, calcium, vitamin A, and vitamin C) were acceptable, other nutrients (thiamin, riboflavin, niacin and iron) and energy were below the recommended levels. Pennington (1976) comments as follows:

> Whether or not the deficit for these 4 nutrients or any of the remaining essential nutrients (which total 45 and are ignored with this plan) are met depends on foods chosen to round out energy needs. If "empty calorie" foods are selected ... the chance of getting adequate nutrients is lessened (p. 4).

Further Pennington (1976) states that "the major problem with the Basic Four seems to be the nonuniformity of major and coincidental nutrients ... within the groups" (p. 6). Thus, the Basic Four food group concept intentionally provides for only 4 nutrients out of a possible 50 or so. The observed nonuniformity of the index and other coincident nutrients in the Basic Four plan would indeed indicate potential fallibility of the plan.

In a more recent evaluation, King et al. (1978) compared the nutrient content of 20 published menus based on the Basic Four Food Guide with the 1974 Recommended Dietary Allowance (RDA) for an adult reference male. The Basic Four Foods met or exceeded the RDA's for only 8 of the 17 evaluated nutrients. For 5 of these nutrients, menus supplied 60 percent or less of the standard. A modification of the Basic Four Food Guide for adults was suggested, in order to improve the adequacy of menus developed from this guide.

Two studies of food guides were also undertaken in Canada. In the first Canadian study, Milne et al. (1963) compared nutrient intakes to patterns of food usage for adolescents. They found teenagers may consume nutrients in recommended amounts without ingesting foods in the amounts suggested in Canada's Food Guide. Similarly, McClinton et al. (1971), in the second Canadian food use study, indicated a wide divergence between patterns of foods recommended in the food guide, and those patterns of foods selected by the study population. Out of 1,418 people who met the recommended allowance for nutrient intake, only one person included foods as recommended in the Canada Food Guide. These results agree in concept with the findings of Pennington (1976). On the other hand, these findings do not necessarily evaluate the educational effect of the food guide. The fact that the population sampled had adequate nutrient intakes may reflect favourably on the educational efficacy of the food guide, if in fact the food guide had served as a basis of instruction.

2.2.1.2 Inapplicability to the Present Food Supply

Present food guides have also been criticized as inapplicable to present food supplies because of the trend, in western society, towards the use of highly refined fabricated foods, and of nutrient supplements (Bogert et al. 1973; Hertzler and Anderson 1974; Fremes and Sabry 1976). The development of an effective food guide requires that the food supply, and consequent pattern of food usage, have a reasonably consistent nutrient distribution which allows translation of the foods into a limited number of food groups. Many of the synthetic and fabricated foods may be concentrated sources of one or more nutrients which reflect those in a food group but do not supply sufficient amounts of other nutrients. Thus, although the food guide is presumed to give reasonably sound information on a diet selected from a limited number of natural food groups, many of the manufactured items presently available which resemble natural foods and may in fact replace items in the food plan, do not compare favourable in nutrient content (Bogert et al.1973; Hertzler and Anderson 1974; Fremes and Sabry 1976).

2.2.1.3 Relevance to Contemporary Nutrition Problems

Food guides have been criticized for their lack of relevance to the present nutrition problems of the population. A food guide is a tool to improve eating habits and consequently it should indicate where improvement is needed. Food guides, although revised occasionally, were developed at a time when nutrition knowledge was not as extensive as today, and when emphasis on dietary needs was different (Hertzler and Anderson 1973). For example, Canada's Food Guide was originally established in 1942, at a time when the needs of national defense dictated a policy of food allocation and rationing practices. However, as suggested by Fremes and Sabry (1976), the nutritional problems of today are not ones of shortage, as they were during the war years, but problems of abundance.

Bogert et al. (1973) states that in developing a food guide the goal is to " ... add to the scientific basis of the Four Food Groups, making finer distinctions and discriminations among the group alternatives based on newer knowledge of nutrients and the foods in which they occur" (p. 442). Examples of this evolution exist (Hertzler and Anderson 1974). For example, embellishments to meet particular needs have been incorporated in food guides, such as indications of vitamin D requirements, and provisos for the use of iodized salts. Similarly, subclassification of the fruit and vegetable group has been used to discriminate foods rich in vitamin A and C. Modern examples of food guides for use by vegetarians (MacMillan and Smith

1975; Smith 1975) and for coronary prevention (Conner 1967; Jansen et al. 1975) are available on a limited basis. However, these guides must necessarily incorporate additional food groups or qualifying remarks to direct food choices.

2.2.1.4 Ineffectiveness as a Teaching Tool

To clarify the concept of healthful food selection and to facilitate learning, the need for maximum simplicity in food guide design has been stressed. Simplicity has been obtained by limiting the number of food groups and by using familiar names of foods (Hertzler and Anderson 1974). However, the trend in North America to attain maximum simplicity may not be as practical today as in earlier years, consequently, some authors have questioned the present food guide approach as the exclusive model for teaching food selection. (Hayes et al.1955; Anon 1972; Lachance 1972; Poolton 1972; Manoff 1975).

The media and advertising in the current era of food fads and fad diets have made the public aware of the basic nutrients, and a host of other food-associated claims (Ullrich 1971). Simple food-grouping systems may not be effective as teaching tools because the increased impact of media on nutritional awareness has established issues to which nutritional instruction by food guides does not adequately respond (Anon 1972; Lachance 1972; Manoff 1975).

Another criticism of the food guide as a teaching tool has been the effect on interest in nutrition observed when it has been used extensively and repeatedly through several years of nutrition education (Poolton 1972; Bogert et al. 1973; Leverton 1974). Food guides do not adequately hold peoples' interest and consequently their ability to learn suffers. As Lachance (1972) stresses, " ... teaching nutrition by food groups is like teaching mathematics by astronomy. It can be done, but it's not exactly the optimal method" (p. 44)

2.2.2 Other Relevant Systems

The food guide is not the only method for presenting the principles of appropriate food selection. As indicated there are reasons that a more elaborate teaching tool should be considered to replace or supplement the present food guide. The sacrifice of the food guide's simplicity may be substantially offset by benefits in both teaching effectiveness and accuracy of nutritional information. Such tools include: food labelling (Anon 1973), the Dietary Nutrient Guide (Pennington 1976), and a variety of computerized dietary assessment programs (Hanson 1969; Hansen 1973; Johnson et al. 1974; Eddison 1975; Action B. C. 1976; Kugler 1976). These tools provide a nutrient-emphasis rather than the more traditional food-emphasis.

2.2.2.1 Pennington's Dietary Nutrient Guide

Pennington (1976) has developed a "Dietary Nutrient Guide" for evaluating diets which utilizes a limited number of "index" nutrients to monitor the total nutrient contribution of diets. Adequacy of the seven index nutrients ensures adequacy of other essential nutrients provided a few other guidelines are followed. The concurrence of index and other nutrients in foods has been determined by using extensive statistical analysis and computer procedures.

This approach does circumvent the inadequacies of the traditional food guide by ensuring adequacy for 45 nutrients rather than four. Pennington has been able to avoid the usual pitfalls encountered when the dietary standard is translated into food guides or other patterns for desirable eating -- that is, to deliberately or inadvertently ignore many essential nutrients in order to simplify the computation required in order to group foods.

It is interesting to note that the index nutrients identified by Pennington, as indicative of dietary quality in conventional foods, are not those customarily recognized as key nutrients in food guides and which presently appear as key nutrients in nutrition labelling. Pennington's seven index nutrients are vitamin B-6, magnesium, pantothenic acid, vitamin A, folacin, iron, and calcium.

2.2.2.2 Nutrition Labelling

Nutrition labelling, as defined in the 1973 U. S. Code of Federal Regulations for food label information panels (Anon 1973), outlines conditions for voluntary and mandatory declaration of nutrient composition information on food products. While nutrition labelling is not solely and specifically designed as a nutrition education device, it can be "exploited" for nutrition education purposes (Moore and Wendt 1973). Thus, nutrition labelling provides a reference standard for directly comparing the nutritive value of foods, and illustrates the major nutrient contributions of products whether or not they correspond to the food group concept. It also acts as a planning guide for balancing meals by providing clues to selecting food combinations which contain adequate amounts of key nutrients. Moore and Wendt 1973 suggest that nutrition labelling uses " ... a technically sound vocabulary for describing the nutritive quality of foods ..." (p. 123) -- that is, objective nutrient information on specific food products -- rather than a " ... contrived index of nutritive quality that sacrifices accuracy for oversimplification" (p. 122).

Although Moore and Wendt (1973) support the use of percentage of the

U. S. RDA per serving or portion as a more practical and meaningful method of providing nutrient content information than either nutrients per calorie or nutrients per unit weight, other authors (Wittwer et al. 1977) have promoted the use of nutrients per calorie or nutrient density. Nutrient density is expressed as an "Index of Nutritional Quality" which is the ratio of a food's nutrient contribution as a percentage of the nutrient allowance, to its caloric contribution as a percentage of the energy requirement. An index value of 1.0 for a nutrient is the basic goal.

2.2.2.3 Computer Applications in Nutrition and Dietetics

During the previous decade, electronic data processing and system design have been extensively applied in food service systems management, hospital dietetic departments, dietetic education, and nutritional research centers to perform a variety of functions (Hoover 1976).

Computers have been variously utilized: in hospital dietetic departments and nutrition-research centers to perform nutrient analysis on a variety of dietary data (Brisbane 1964; Hjortland et al. 1966; Schaum 1973); in diet- and menu-planning procedures which allow simultaneous satisfaction of nutritive, production, economic, and palatibility constraints (Smith 1963; Gelpi et al. 1972; Balintfy 1976); in patient- and hospital-information systems to support patient care activities such as menu ordering and production (Schaum and Sharp 1973); in obtaining dietary histories by automated-interactive interviewing (Evans and Gormican 1973); and in various other areas of nutrition research such as the study of eating patterns (Pao and Burke 1974). Computer-assisted systems have also been used extensively in food services to provide automated control of resources (Andrews et al. 1967; Tuthill and Moore 1974), and in food production (Fleetwood et al.1974; Sager 1974).

In addition to the industrial, clinical, and research applications of computers in dietetics and nutrition mentioned above, systems utilizing some of the same functions are available to support nutrition education activities. These systems include Dietronics (Hanson 1969), Nutrimetrics 07 (Eddison 1975), the Nutrient Adequacy Reporting System (NARS) (Johnson et al. 1974), the Nutrition, Health and Activity Profile (Kugler 1976), the Nutrient Quality Index (Hansen 1973; Sorenson and Hansen 1975; Sorenson et al. 1976; Wyse et al. 1976; Wittwer et al. 1977), and the Action B. C. nutrition evaluation program (Action B. C. 1976). In addition to their potential nutrition education function, some systems, in particular Dietronics and NARS, were designed as dietary-screening devices for clinical use.

All of these programs are designed primarily to evaluate individual's diets, by providing information on the nutrient characteristics of the diet in relation to the estimated needs of the individual. Nutrient analysis and evaluation are performed on information from self-administered dietary questionnaires. Food composition data is recorded as one (Action B. C. 1976) or two-day recalls (Eddison 1975), as records of one (Johnson et al. 1974) to seven days (Hanson 1969; Action B. C. 1976), or as usual consumption pattern (Hanson 1969; Kugler 1976). Additionally, client demographic data are collected on the questionnaire and used for estimating the client's nutrient needs.

The various systems employ computer-generated outputs which provide information on nutrient consumption with a comparison of nutrient intake to anindividualized dietary standard for between one (Eddison 1975) and 25 nutrients (Hanson 1969; Kugler 1976). This information is usually displayed as actual nutrient intake and/or percentage of the nutrient allowance. Additionally some programs include information on nutrient ratios and percentages (Hanson 1969; Kugler 1976); the number of servings in the diet from each of the food groups (Hanson 1969; Johnson et al. 1974) and other dietary measures such as sucrose consumption (Hanson 1969; Kugler 1976) and plaque frequency exposure (Hanson 1969). NARS also provides an overall measure of nutrient adequacy for the client, by averaging the percentage of the recommended allowance obtained over 12 nutrients. Although most systems provide tabular displays for the results of analysis and evaluation, the Nutrient Quality Index utilizes a graphical display.

In some systems instructional material is appended to, or forms an integral part of the output, so that the results of the nutrient analysis and evaluation can be retranslated to an eating pattern. Nutrimetrics 07, which analyses the diet solely for caloric intake, prescribes caloric restriction where required to achieve ideal body weight by identifying and suggesting limitation of low-nutrient density foods, such as alcoholic beverages and sweets. The Action B. C. program output provides summary statements on desirable items to include in the diet when a nutrient is limiting. Information on nutrient functions and a recommended activity program for weight loss is also available.

The most elaborate output from the systems available is the Nutrition, Health and Activity Profile which proves a 9 to 13 page computer-generated response incorporating extensive discussion on diet and other aspects of lifestyle. Another form of prescription is utilized in the Dietronics output. Brand-name nutrient supplements are recommended to supply those nutrients falling below the nutrient standards.

These examples illustrate some of the present uses of computer systems in dietetics and food services, and particularly in nutrition education. As Hoover (1976) indicates, in her review of computers in dietetics, the next decade may bring more extensive use of computers in present areas, and the exploration of further computer applications in dietetics and nutrition. Present computer technology offers more capabilities than have been presently exploited in nutrition. While the computer is the tool used to perform the operations required in the above systems, the operations have nothing to do with the computer per se. However, the solution of problems, and performance of tasks of realistic size cannot be practically attempted without the aid of high-speed computers. The computer is a tool which can be effectively utilized in situations where rapid error-free processing is required. For example, the numerical manipulations, report preparation, and other routine decision-making functions found in many areas of dietetics and food services make effective use of computer methods. Within these limits the computer has demonstrated substantial advantages in cost and time-saving over conventional methods.

2.2.3 Critique and Conclusions

To develop a teaching tool or guide which is generally useful is not an easy task (Ullrich 1971). As indicated in Section 1.1, the complexity of present food markets, of dietary issues influencing health, of sources of nutrition and food related information, and of communicating to a public with a diversity of needs and levels of knowledge, must be considered in designing any tool providing information on food selection practice. This information provides a guideline for both the assessment of present practices and a goal for directing dietary modifications. The acceptability of any system for food selection instruction depends on the worth of these two functions -- assessment and prescription.

The food guide has attempted, as Bogert et al. (1973) suggests, to "... combine scientific knowledge with Western cultural wisdom and, faulted though it is, there is not now an equally simple, equally workable alternative plan for Western food patterns" (p. 422). On the other hand, Pennington (1976) comments;

> A workable and usable food guide should be reliable and understandable but it need not be overly simplified. The Basic Four, as presently used is oversimplified and is certainly not foolproof (p. 7).

Unlike the food guide the other systems discussed have potential capabilities of monitoring most of the known nutrients in the diet, and in this sense are theoretically less fallible guides for assessment of food selection practices. The use of nutrients as the basis of assessment provides an objective foundation on which to effectively coordinate nutritional information effectively with available food supplies and consumer habits. But these systems have been criticized for this detailed information allegedly exceeding the average consumer's comprehension (Moore and Wendt 1973). Unfortunately, after elaborate analysis and evaluation of the client's diet, these systems must then utilize less accurate methods to generate a food plan, such as the food guide or a listing of primary sources of nutrients.

Neither of these concepts -- the food guide with its traditional food-emphasis nor nutrition labelling with its nutrient-emphasis -- are designed to stand alone (Moore and Wendt 1973; Winarski 1976). They both require the informational skills of a nutritionist/dietician to interpret nutrient information and to develop a dietary plan. Presumably the computer systems discussed also require some supplementary instruction to ensure the development of a viable food plan. However, unless the professional has specific auxiliary tools available, the effectiveness of assessment and prescription will be limited by the capacities of the food guide and nutrition labelling.

Although the nutrition educator should play an integral part in programs for instruction in food selection practices, the actual interpretation and translation of food and nutrient information to human diets may be a mathematical and technologic problem (Balintfy 1973; Balintfy 1976). The logic of mathematical modelling, and the data handling capability of computers may be required to resolve the conflict between the requirements for accuracy and for simplicity in the design of systems for food selection instruction.

As indicated, several computerized systems for dietary analysis and evaluation are available for nutrition education. These systems provide useful feedback on the adequacy of present practices through accurate and comprehensive assessment of individual diets. Although no computerized nutrition education tools which provide individualized diet or menu planning are presently available, illustrative models do exist in hospital food services and other industrial applications. These systems allow for simultaneous satisfaction of a large number of variables including nutritive, economic, and palatibility. These may be adapted to nutrition education purposes to provide recommendations on needed alterations in individual diets, and married to present evaluative programs.

2.3 Dietary Assessment

The objective of dietary assessment is to provide an estimate of a population's or individual's nutritional risk, by accurately estimating food and nutrient intake parameters of a population, group, or individual, and evaluating these parameters against appropriate standards (ICNND 1963; Mongeau 1974; Pike and Brown 1975). Dietary assessment has three phases: first, the collection of data on food intake, second, analysis of dietary data to determine the nutrient intake, and third, evaluation by comparing estimated nutrient intake with appropriate standards.

Dietary assessment is only one of the procedures used in the assessment of nutritional status. Present methods for assessing the nutritional status of individuals includes dietary studies, clinical studies and laboratory investigations (Jelliffe 1966; Christakis 1973). Each of these techniques is important for investigation of nutritional status, and for defining desirable dietary practices. However, only in comprehensive nutrition surveys would all techniques be simultaneously invoked. Otherwise different techniques would be selectively employed depending on the objectives of the study or requirements of the situation.

Nutritional status according to Christakis (1973) is "the health condition of an individual as influenced by his intake and utilization of nutrients, determined from the correlation of information obtained from physical, biochemical, clinical, and dietary studies" (p. 80). Consequently, nutritional status by definition cannot be judged from dietary intake data alone for two primary reasons.

(i) Since the evaluative standard for nutrient intake -- the dietary standard -- is built on a normal curve which has inherent variability and consequently makes the individual's exact requirement unknown, a certain diagnosis of nutrient inadequacy cannot be made from a knowledge of nutrient intake alone (United States 1974; Hegsted 1974). Although it is highly unlikely that intake is inadequate when the dietary allowance or standard is met or exceeded, there still exists a risk that deficiency will occur. Similarly, an intake below the allowance is not, in itself, evidence of nutritional inadequacy. This criticism applied to other methods of nutritional status assessment:

> ... data, like dietary data, have been traditionally interpreted by selecting some arbitrary cut off point, tabulating those who fall below that point, and using this value to indicate the number of "deficient" individuals in the population. Obviously, the significance of any measure of nutritional status - whether based on dietary, biochemical, clinical, or anthropometric data = depends on how it relates to the conditions one is attempting to diagnose or the specificity of the measure and the variability of the measure itself (Hegsted 1975, p. 18).

Any measure of nutritional status can only indicate a degree of risk which may be attached to that measurement. Thus, to assess the nutritional status of an individual, records of nutrient intake should be considered in conjunction with the results of clinical, biochemical, and anthropometric measures. This procedure simply increases the probability of making a correct diagnosis.

(ii) Different methods of assessment are not exactly equivalent. Nutritional assessment tools have sensitivity to different aspects of the deficiency continuum as predictors of risk, and provide different types of information about nutritional status.

Jelliffe (1966) classifies the assessment tools as: direct methods, including clinical, biochemical, anthropometric, and biophysical techniques; indirect methods, such as information on vital statistics; and ecological methods, wich consider food consumption, cultural influences, socio-economic factors, and infectious diseases. Jelliffe's classification illustrates a basic difference in the type of information provided by the different methods. Whereas, the direct and indirect methods of assessment "ideally" identify the consequence of nutrient influence, ecological measures such as diet assessment are used to establish causation. Diet is only one of many factors that may result in poor nutritional status and consequently diet adequacy does not ensure nutritional health.

However, the different utility of dietary assessment methods confers some distinct advantages to its use. Dietary assessment monitors a different aspect of the deficiency risk progression and therefore is an important component of nutritional assessment. The progression from sufficiency to deficiency is illustrated in a model of the development of deficiency diseases as follows. Five stages of interference in metabolism, give rise to progressively more overt clinical symptomatology: first, the preliminary stage with depletion of body stores for a nutrient subsequent to a poor diet, disease, or other conditioning factor; second, the biochemical stage where biochemical defects become apparent due to enzymatic depletion of coenzymes and the like; third, the physiologic stage which presents unspecific clinical findings such as general malaise, and irritability; fourth, the clinical stage where overt clinical signs are evident but tissue pathology exhibits nonspecific syndromes such as skin lesions and anemia; and fifth, the pathologic stage where specific syndromes exist and pathology has progressed to more vital functions (Krehl, W. A. 1964).

Although there is actually considerable overlap in the specificity of the methods for monitoring the risk continuum, it would appear that " ... dietary information should be the most sensitive method of anticipating risk of deficiency" (Hegsted 1975, p. 18) from dietary origin. Also, dietary assessment may provide cues to nutritional problems that may not be evident from other methods.

In summary, dietary assessment procedures aid in the interpretation of other survey findings by, first, contributing to the diagnostic sensitivity of nutritional status measurements, and second, by providing etiologic clues to morphologic, biochemical, or functional abnormalities. Assessment by itself is of limited value without knowledge of causation, since this is important for defining corrective measures. Additionally, dietary assessment acts as an indicator of early nutritional risk, and provides mechanisms to detect risk of nutritional problems where clinical and biochemical procedures are either not sensitive or are presently unavailable. Consequently, as a public health tool, dietary data have considerable merit in that this serves as the earliest preventive nutritional health monitor.

Thus, while recognizing the limitations of defining nutritional status by dietary status alone, dietary assessment can be an effective public health tool to provide evaluation of food selection practices of individuals -- and in fact may be the only practical method to do so.

The following three sections deal more specifically with the three phases of dietary assessment -- data collection, analysis, and evaluation -- and how they can be best incorporated into a system to provide instruction on food selection practice.

2.3.1 Data Collection

2.3.1.1 Data Collection Methods

> "The aim of all dietary surveys, whether made on individuals or on groups, is to discover what the persons under investigation are in the habit of eating. Their diets must be those to which they are accustomed and which they freely choose" (Marr 1971, p. 108, quoting Widdowson).

Methods are available to collect data on the intake of populations (ICNND 1963), several hundreds of individuals (Paul et al. 1963), families or households (ICNND 1963), and individuals (Chappell 1955; Taggart 1962). The present concern is with data collection on individuals.

Food consumption data on individuals may be collected, according to the schema presented by Marr (1971), in the following ways:

(i) Present intakes of food can be recorded by weighing methods. The weighing methods can be divided into two types, the precise weighing method and the weighed inventory method (Marr 1971). Both are applicable to the free-living individual, unlike metabloic balance studies which require controlled laboratory conditions (Wilson et al. 1964). With the precise weighing method, all ingredients used in the preparation of dishes, the inedible wastage, cooked portions of food, and the plate waste are recorded. The weighed inventory method only requires that the prepared food be weighed immediately before consumption and the plate waste be weighed at the end of the meal. In either method, the actual measurements of foods eaten may be under the investigator's control (Pekkarinen and Roine 1964). Analysis of the diet may be chemically determined from aliquot samples or may be calculated using tables of food composition.

(ii) Present intakes of food can be recorded in household measures. This method, as described by Marr (1971), requires that the record of the food eaten, over a period of usually three to seven days, be described in terms of household measurements or be compared in size with food models. These descriptive terms are then converted to weights which are used for assessing the nutrient and caloric intake by using tables of food composition. Although direct supervision is not necessary, where cultural patterns do not predispose to systematization, or where literacy is low supervision may be required.

(iii) Present intakes can be recorded as a menu. The problem of collecting dietary data on large groups of individuals for epidemiological study, has prompted the development of methods which require only a minimal amount of data from the subjects (Wiehl and Reed 1960; Marr 1971). This method measures the foods consumed over the study period as a menu without quantities. The assumption, when using unquantified intake instead of a measured or weighed intake, is that the size of helping does not vary to any great extent between individuals, or at least not to such an extent that course measures of dietary quality cannot be determined. In some cases factors corresponding to the amount of food in an average portion, or derived from multiple regression analysis, are applied to the frequencies to obtain quantitative approximations of foods or nutrients consumed (Mongeau 1974).

(iv) Past intakes of foods actually consumed can be recalled. This method measures actual past intakes as remembered at an interview (Adelson 1960; Guggenheim et al. 1960; Huenemann et al. 1961; Bransby et al. 1964) or on self-completion questionnaires (Keen and Rose 1958). The subject is usually asked to recall all food consumed during the previous day and to estimate quantities in ordinary measures or servings. To facilitate quantitication estimation aids such as food models and measuring utensils may be utilized in interviews, and have also been used in questionnaire methods (Johnson et al. 1974). Customarily, foods eaten in the previous 24 hours are recalled -- and for this reason the technique is usually termed the 24-hour recall --, although recalls covering up to the previous three days (Guggenheim et al. 1960) and for periods of one week (Huenemann et al. 1961) have been reported.

(v) Past intakes of foods usually consumed can be recalled. The diet history method obtains data on general dietary pattern, as opposed to current diet or past foods actually eaten (Pekkarinen 1970). The method, developed by Burke (1947), makes use of several different approaches to obtain information from an individual about average food intake over a period of time. The three phases of the diet history are, first, a determination of the past pattern of eating by using the 24-hour recall coupled with inquiry about the usual eating pattern. Second, using a detailed predetermined list of foods, the pattern of eating reported in the first section is cross-checked to determine inconsistencies and inaccuracies. Finally, a three day food record of present intake in the form of a non-quantified menu is kept by the subject. The results of the history are recorded in household measures, and are converted by use of food composition tables to their nutrient values. The reliability of the data on usual consumption, obtained by the first phase of questioning, is verified by the later two phases, for which reason the method is called the cross-check dietary history (Hartog et al. 1965). Burke (1947) indicates the history method is suitable only when a well defined dietary pattern exists.

vi) Past intakes of foods can be recalled as an unquantified menu.

In addition to short-cut methods of data collection by recording, abbreviated methods for collection of recalled dietary data have been developed. These are radically shortened versions of the Burke method which measure usual frequency of consumption data. Both interview (Stefanik and Trulson 1962) and questionnaire formats (Hankin and Huenemann 1967; Hankin et al. 1967; Balogh et al. 1968) have been tested.

2.3.1.2 Evaluation of Data Collection Methods

Although a variety of techniques for determining dietary intake for free-living individuals are available, none has received general acceptance. Indeed as Marr (1971) points out, controversy has raged over what constitutes the best method. She indicates that perhaps the "extremes of considered opinion" (p. 109) are respectively illustrated in the views of Widdowson and of Burke. The former emphasizes "the necessity for [accurate] measurement of current intake and the other the need for assessment of [representative] food habits over a considerable period" (Marr 1971, p. 109). Thus, there are conflicting views on the value of accurate measurement which arise primarily because procedures to maintain validity of measurement may interfere with the representativeness of the sample population, or with the eating patterns of that population (Thomson 1958; Mann et al. 1962; Marr 1971). Mann et al. (1962) complains in response to this confusion, that " ... a superficial examination of the technical problems experienced in measuring dietary intake meets such a morass of conflicting opinions that the first inclination is apt to be a decision for abandonment" (p. 212).

Pekkarinen (1970) and Marr (1971) indicate, in part, the problem of appraising dietary intake methodologies is that no independent device, or absolutely accurate method of dietary data collection, exists against which the validity of the methods used in dietary assessment can be measured. The validity of each method can only be tested comparatively (Marr 1971).

Although no single ideal method exists, each method has its advantages and disadvantages. Consequently, the choice of method, its potential and validity, must be assessed against the objectives and purposes of the study; and against the circumstances in which the technique is to be used, for example, funds and personnel available for the study, and the study population's characteristics.

In terms of validity of measurement alone the precise weighing technique, with investigator supervision and analysis of aliquot samples, theoretically is the method providing the most valid estimate of actual food and nutrient intake (Marr et al. 1959; Whiting and Leverton 1960; Marr 1971). The weighed inventory method with investigator supervision and analysis of aliquot samples would be expected to be a close second. However, the expense required for performing weighing methods, (Pekkarinen and Roine 1964) and the intrusive nature of the collection procedure (Marr 1971), limit the utility of such studies to small, often non-randomized populations of cooperative individuals (Pekkarinen and Roine 1964; Hartog et al. 1965), and to relatively short periods of reference -- one or two weeks is generally considered to be the maximum duration (Pekkarinen 1970). Further, the intrusive character of the weighing techniques may interfere with normal behavior and thereby limit the validity of the measurements (Pekkarimen 1970; Marr 1971). "To what extent this [intrusion] alters the food intake is difficult, if not impossible, to determine" (Marr 1971, p. 110).

Inconsidering other methods, it must then be determined to what extent measurement validity is influenced by the various departures which are necessary in practice to reduce costs and improve subject cooperation, such as: the use of food composition tables instead of chemical analysis for nutrient analysis (Marr 1971); the use of subject versus investigator measurement for data collection (Paul et al. 1963; Marr 1971); the use of descriptive measures or no measurement instead of direct weighing (Bransby et al. 1948; Young et al. 1952a; Thomson 1958; Marr 1971); and the reliance on memory in recall methods rather than on direct observation (Huenemann et al. 1961; Marr 1971; Mongeau 1974). The loss in accuracy of measurement can in turn be judged against the increased usefulness of data derived from representative samples of a population living their normal lives, for which the weighing methods are not a practical technique (Marr 1971). The less intrusive methods encourage greater subject cooperation resulting in opportunities for longer term studies of larger sample size with randomized samples; and for reduced interference in eating pattern (Pekkarinen 1970; Marr 1971). Data collection at relatively lower cost also permits increased sample size and longer time frame (Marr 1971).

2.3.1.2.1 Validity and Repeatability of Methods

Although absolute validity for the weighing methods cannot be established; relative validity has been demonstrated by comparing weighted surveys with the results of other dietary data collection methods (Marr 1971). The weighed inventory method has also been indirectly validated, Durnin (1961) found that caloric expenditure, as measured by indirect calorimetry, and energy intake determined by the weighed inventory method were balanced over seven days. Tests of repeatability show reasonably consistent results with both the precise weighing method (Marr et al. 1959) and the weighed inventory method (Heunemann and Turner 1942; Adelson 1960).

Compared to data recorded by weighed methods, data recorded in household measures and descriptive estimates are considered less precise largely because of errors in estimation of portion size (Young et al. 1952a; Thomson 1958; Marr 1971). Interestingly, in a study conducted by Bransby et al. (1948), comparisons of weighed and measured intakes for both individuals and groups did not show marked discrepancies, providing the measuring equipment was standardized.

Dietary records collected as menu items without an indication of quantity are considered less precise than either weighed methods or those using household measures. However, investigators (Marr 1971) testing the utility of frequency-of-consumption information indicate it was accurate enough to classify populations into broad categories with respect to nutrient intake.

According to many investigators, grouped mean intakes from recalls of actual intakes and those from weighed records (Morrison et al. 1949; Adelson 1960; Combs and Wolfe 1960), estimated records (Payton et al. 1960), or diet histories (Stevens et al. 1963) give comparable results and thus can replace each other in group surveys. This is so particularly if samples are large and if daily and seasonal variations in intake are small (Pekkarinen 1970). However, agreement of grouped data between recalls and other methods is not found in every case (Bransby et al. 1948; Young et al. 1952c; Trulson 1954; Thomson 1958; Pekkarinen et al. 1967). When individual consumption is sampled, variation in intake data are observed between dietary recalls and other methods by some investigators (Morrison et al. 1949; Young et al. 1952c; Trulson 1954). This finding is not universal.

Some authors find that when individual consumption is sampled over the same time frame (Flores et al. 1965), or even different time frames (Adelson 1960), results of recalls and weighed records are in good agreement.

Considering the dietary history method, Balogh et al. (1968) have found comparable results from the history method and a weighed record. However, in most cases (Huenemann and Turner 1942; Young et al. 1952b; Trulson 1954; Paul et al. 1963; Hartog et al. 1965; Hart and Cox 1967), attempts to validate dietary histories against weighed or measured food records have demonstrated discrepancies between the methods for group and individual values, particularly when surveying children (Trulson 1954; Beal 1967). Repeatability of the dietary history method had been demonstrated by repeat histories (McCann et al. 1962; Paul et al. 1963). Burke et al. (1943) provides some evidence that indirectly validates the dietary history method. In this study the results of a diet history was validated against an independently measured variable -- the incidence of preeclampsia.

Results of validation studies indicate favourable comparisons between the shortened recall methods and research history interviews, weighed, or measured weekly records for group data (Marr 1971). The applicability of this method to individual dietary analysis is doubtful.(Marr 1971).

2.3.1.2.2 Time Frame of Methods

Information on long-term food consumption is the objective of most dietary surveys. The efficacy of extrapolating short-term data to habitual intake is questionable (Cantoni et al. 1961; Pekkarinen 1970; Marr 1971; Mongeau 1974).

Studies using weighed records to explore weekly variations in individual's diets have provided conflicting long term intake. Some authors (Thomson 1958; Morris et al. 1963) believe that seven-day weighed records give a sufficiently accurate estimate of usual intake, since in their study populations considerable individual stability of food intake was found over widely separated weeks. However, others (Yudkin 1951; Keys _et al_. 1966) indicated that a one week survey was not predictive of long term intake. Adelson (1960) reports that for some individuals weekly diet patterns are relatively stable, while this is not the case for other subjects. Authors using weighing methods (Yudkin 1951; Chalmers _et al_. 1952; Chappell 1955; Fidanza _et al_. 1964; Hartog _et al_. 1965; Hankin and Huenemann 1967) have indicated that daily, weekly, seasonal, and yearly variations in dietary intake are evident. The extent of the temporal variations is influenced by factors such as age, gender, and occupation (Chalmers _et al_. 1952; Adelson 1960). Also the different nutrients show different degrees of variability (Chalmers _et al_. 1952).

A general statement about the appropriate length of time to be surveyed using weighing methods, or in fact any method of measurement, cannot be given (Pekkarinen 1970; Marr 1971). The length of time required to establish a representative picture of intake is obviously dependent on the individual's or population's food intake patterns. If extreme variations exist in food intake pattern, no method short of extensive sampling is likely to accurately categorize long term dietary intake. As the variation in the diet decreases the time frame required for accurate estimates of usual consumption can be reduced accordingly. Providing the duration of sampling corresponds to a consistent dietary cycle or rhythm, the sampling frame should be indicative of usual intake. To define the time frame required to record dietary intakes of usual consumption for an individual or group the precision required must be stated, and intake variation per time must be determined for each nutrient and for each sample of the population to be appraised (Marr 1971).

Thus, the efficacy of extrapolating from the sample period depends on the consistency of the dietary pattern (Pekkarinen 1970). Even the diet history method, which is intended to measure long-term food pattern, is suitable only when a well defined dietary pattern exists (Burke 1947). Sampling period can be more effectively lengthened by sampling in a number of separate one week periods over the year (Chappell 1955) or as Balogh et al. (1971) have shown by repeated 24-hour recalls.

2.3.1.2.3 Randomness and Size of Population Samples

A major disadvantage of the weighing methods is that they demand a high degree of cooperation from the individual, consequently response rates in population studies may be low. For this reason, weighing methods may not be suitable in studies carried out on random samples (Pekkarinen and Roine 1964), as has been found in certain countries (Hartog et al. 1965). However, in some other countries (Buzina et al. 1964; Fidanza et al. 1964) the use of weighing methods has not prevented randomization of the survey population. Since records using household measures are less demanding than weighing methods a higher degree of cooperation may be expected. However, Marr (1971) indicates that higher cooperation rates are not necessarily achieved by descriptive as compared to weighed studies.

For all its faults, the 24-hour recall is the only suitable method for use in large scale surveys of heterogeneous populations. The method should allow randomized surveying of large representative sample populations, since cooperation rates would be expected to be high (Pekkarinen 1970; Marr 1971). However, Marr (1971) indicates that little information on cooperation rates in recalled surveys of actual food consumption is available in the literature. The diet history method is also reasonably acceptable for random surveys of large population samples, particularly in its abbreviated forms (Marr 1971).

2.3.1.2.4 Other Methodological Considerations

In addition to the generic features of the dietary-data collection methods, which have been presented above and which contribute to discussions of the relative validity of these methods, several other methodological considerations which effect the accuracy of dietary intake data have been identified. These considerations include: the professional skills of the interviewer or technician doing the data collection (Adelson 1960); the use of auxillary procedures, such as visual aids and models to assist in quantification (Balogh et al. 1968); the characteristics of the diet under study -- its complexity or monotony (Chalmers et al. 1952); the circumstances of the study, such as season undertaken (Mongeau 1974); the study populations characteristics including their skills (Young et al. 1952c; Stevens et al. 1963), age (Marr 1971), attention span, memory capabilities, education, literacy, and intelligence (Pekkarinen 1970); and perhaps a variety of procedural nuances used to reduce errors of portion size estimation and of omission, for example, explicit inquiry about postprandial consumption patterns when doing recalls (Balogh et al. 1968), and a detailed interview following completion of client records to enable the quantities and size of helpings to be checked (Kitchin et al. 1949).

The accuracy of data collection methods may be greatly influenced by situational factors, as those above. For example, in quantitative studies using estimation methods, the ability of the subject to accurately estimate quantities is important for achieving accurate results. Stevens et al.

(1963) and Young et al. (1952c) found good agreement between methods when using informed subjects, such as Home Economics graduates, whereas the results from other groups of subjects provided inconsistent answers. Presumably had all the subjects in the experiment been able to estimate quantities accurately, the conclusions reached by these authors on the comparative accuracy of the methods would have been different. Present comparative studies of data collection procedures have not explicitly addressed the impact of these factors on the accuracy of methods or their possible importance for defining the exact method appropriate for every field situation. In this regard, new methods are being proposed and developed (Mongeau 1974). Explorations into short schedule epidemiological methods (Hankin and Huenemann 1967) are being made.

2.3.1.3 Summary and Conclusions

Evaluation has identified some of the limitations and potentials of each method. The basic problem is that it is difficult, and perhaps impossible, to measure accurately the dietary intake of a large random sample of free-living individuals for long periods of time (Marr 1971), particularly if extreme daily variation in intake exists (Christakis 1973). No method presently available ensures, simultaneously, validity of measurement and relatively unbiased sampling and experimental methodology. That is, attempts to ensure absolutely accurate measurement in most cases do not permit data collection from large samples of people, from random samples of those populations, for long periods of time, and from free-living individuals.

As indicated by Marr (1971) and Pekkarinen (1970) the choice of any method -- its acceptability -- is dependent on the characteristics of the population considered, the purposes of the study, and the circumstances of the study. Each situation and study purpose has its own best data collection method. Similarly, each of the methods has its own specific utility. Any consideration of the acceptability of a method must take into account the purpose and situation for which the method was designed.

In the present evolving field of collection methodology for dietary data, definition of an appropriate method for any given situation may be dependent on more than simply selection from the available genera of study procedures. Available methods provide guidelines from which to define some aspects of procedure; beyond this, in order to ensure an accurate record of the types of foods eaten and the quantities consumed, the standard protocol must be modified and elaborated as dictated by circumstance. Thus, both the application as well as the choice of method are significant in determining the accuracy and acceptability of any method.

2.3.2 Data Analysis

Beyond choosing how to collect dietary data representative of an individual's intake, and choosing how a particular intake is to be judged, analysis of the dietary intake data is required to provide indices for evaluation. These indices may take the form of nutrient values (Marr 1971), information on foods and food groups (McClinton et al. 1971), or alternatively, dietary scoring patterns (Trenholme and Milne 1963). For the purposes of this thesis, analysis which provides nutrient composition information reflective of the actual nutrient intake is required.

Two methods for determining the nutrient content of diets are available. These are calculation of nutrient values from food tables and nutrient analysis by chemical methods. Whiting and Leverton (1960) indicate that, laboratory analysis of individual foods, or of composites, provides the most reliable estimate of the nutrient values of foods actually eaten. However, the laboratory procedures and data collection practices needed to secure food samples for analysis, require careful and time consuming handling. Consequently, available resources generally limit use of these methods to special studies.

More commonly, nutrient values are calculated from food tables -- a practice for which the merits have been debated (Harris 1962; Marr 1971). Reflective of the dichotomy of opinions, Widdowson and McCance (1943), in their discussion of the scope and limitations of food tables, wrote:

> There are two schools of thought about food tables. One tends to regard the figures in them as having the accuracy of atomic weight determinations; the other dismisses them as valueless on the ground that a foodstuff may be so modified by the soil, the season or its rate of growth that no figure can be a reliable guide to its composition. The truth, of course, lies somewhere between these points of view (p. 230).

Comparisons of nutrient determinations using food tables with those using chemical analysis, on either group mean or individual data, show somewhat contradictory results. Some early studies (Bransby et al. 1948; Groover et al. 1967) conclude that substantial differences exist between the two methods. They suggest that calculated values do not represent actual nutrient consumption. Interestingly, a reexamination of the study of Bransby et al. (1948) by Marr (1971) suggests that although absolute agreement between analyzed and calculated values for every individual was not achieved, the conclusions reached by Bransby et al. were overly harsh. Marr found that the calculated and analyzed values were essentially the same for individual and group means. Other authors (Buzina et al. 1966; Pekkarinen 1967) indicate relatively good agreement between calculated and analyzed results. Whiting and Leverton (1960) find that whereas the group mean values for some nutrients agree using the two methods, others do not.

Differences between the results of the methods depend primarily on how closely the food composition table value corresponds to the nutrient values of the food consumed. Obviously, if the values assigned by food composition tables are the same as the laboratory results, the calculated and analyzed results for a given portion of food will agree. This is illustrated in studies where food tables composed largely of analytic data of local foods are being used. In such cases the results of calculation and analysis have been found to agree (Pekkarinen 1967). Furthermore, closer correspondence of analyzed and calculated values is achieved with nutrient values that are more stable, such as those for energy and protein (Whiting and Leverton 1960). Where the food compositional values may vary widely, for example with fat values, the differences between calculated and analyzed values may be larger (Whiting and Leverton 1960). It is important, therefore, that the food tables used should be appropriately matched to the foods which are eaten and analyzed, if exact correspondence between laboratory and computational methods is desired.

In comparing food values obtained by analytic methods with those by calculation from food tables, it should not be expected they would agree exactly. The two methods measure somewhat different information about foods consumed. The analytic value determines the nutrient intake of foods eaten on those days of the study, the calculated value determines the nutrient intake based on food composition which represents the average of food samples taken over an extended time period; perhaps a year or more.

Although small special purpose food tables and simple tables for local studies exist, in a complex marketing economy such as North America, it is not useful to disaggregate compositional values for all the local factors that effect nutrient values. Thus, food tables in common use in North America (Watt and Merrill 1963; Church and Church 1975; Adams 1976) contain food compositional information for the country or area which is averaged for factors such as: genetic differences -- variety or breed; environmental effects, for example soil fertility, fertilizers, diet for animals, light, temperature, precipitation, and other climatic elements influencing conditions of growth; seasonal and geographic differences; methods of harvesting, handling, and storage; and manufacturing and processing procedures (Asenjo 1962; Watt and Merrill 1963).

Averaging across factors which create variability in nutritive values is done in order to develop a final figure as representative of the product available the year around for the area considered (Watt and Merrill 1963). Additionally, the statistical procedures used may incorporate averages weighted according to pertinent factors, such as availability or use; other adjustments in the figures, such as excluding widely discrepant results from the final calculations, may be used so that representative figures are developed (Whiting and Leverton 1960; Watt and Merrill 1963). Food values in the 1945 U. S. Department of Agriculture publication, "Tables of Food Composition in Terms of Eleven Nutrients (United States 1945), the 1950 and 1963 editions of Agriculture Handbook No. 8 (Watt and Merrill 1950; Watt and Merrill 1963) are treated in this way.

Although averaging the compositional values in this way adds potential variability to nutrient values calculated from food tables when compared to analyzed figures, a certain advantage is attached to the use of average values. When information on usual consumption is desired, then, providing that the average values are reflective of the actual food consumed, the use of food composition tables with average values provides values which are unbiased by season and other variations in food supply throughout the year.

In addition to the questions about the suitability of calculations of nutrient values from food tables raised due to the variation between analyzed and calculated values, there are other limitations when using nutrient analysis from food tables. Some of these problems are common to chemical methods.

(i) Standard food composition tables (Watt and Merrill 1963) have not provided information on all the nutrient values in dietary standards, and the standard itself does not provide requirements for all known essential nutrients (United States 1974), Hertzler and Hoover (1977) suggest that:

> Although more analyses are needed for every nutrient, new tabulations are especially needed for: vitamin E, molybdenum, phosphorus, iodine, chromium, manganese, selenium, amino acids, and individual carbohydrates. Analyses of dietary fiber are needed because crude fiber represents only a fraction of total fiber in foods (p. 22).

Recent progress in the development of larger composition tables may largely rectify this difficulty (Schaum et al. 1973; Hertzler and Hoover 1977).

(ii) Food tables do not include values on compounds known to interfere with nutrient availability, nor do the chemical analysis on which the tables are based estimate the true availability of all nutrients. Hence, calculations from food tables may overestimate the amounts actually absorbed (Harris 1962; United States 1974). However, in the 1963 Agriculture Handbook No. 8 (Watt and Merrill 1963) foods with high oxalic acid concentrations are footnoted with respect to availability of calcium. Also, although the total amounts of iron, sodium, potassium, and magnesium in foods are listed, the amounts available to the body are recognized as variable by this publication.

(iii) Although until 1940 food tables produced by the U. S. Department of Agriculture listed maximum, minimum, and average values for nutrients when more than one analysis was available (Herzler and Hoover 1977), present tables of nutrient composition to not indicate the variability of nutrient values used to determine the average values (Whiting and Leverton 1960; United States 1974). Thus, while ranges of values would provide some guidance for reliability of calculations, present calculations can only be done from the mean and not the range.

(iv) Nutrient analysis is needed for many items, such as: ethnic foods; restored or supplemented items; products with new formulations; and dehydrated, frozen, and ready-prepared products (Hertzler and Hoover 1977). Regradless of the extent of food table development, difficulties will probably still exist in: monitoring constantly changing manufacturing practices; describing all the variations of preparation practice such as cooking time; and providing food names which cover all local idioms.

Regardless of the problems encountered with the use of food tables, resource limitations and circumstances necessitate that nutrient analysis be performed using food composition table values. This applies especially when the intakes of large numbers of people are monitored for many nutrients.

Numerous tables of food composition have been developed in North America since the 1890's. This history has been recently reviewed by Hertzler and Hoover (1977). In one of the first comprehensive tables of nutrient composition for American foods, Atwater (1895) included values of calories, protein, fat, and carbohydrate for approximately 235 items. Since that time advances in nutrition knowledge, refinements in laboratory procedures, expansion in the number of foods available, and a trend towards increased specificity for most nutrient classifications have resulted in food composition tables of considerably larger size. A projected development of a data bank by the U. S. Department of Agriculture will consider up to 215 food constituents for an undefined but potentially enormous number of foods (Hertzler and Hoover 1977).

Tables of food composition used in North America have as their basis tables developed primarily by the U. S. Department of Agriculture. The most comprehensive of these tables, among the bibliography of the USDA food composition publications provided by Chandler and Perloff (1975), is contained in Agriculture Handbook No. 8. This volume was first published in 1950 (Watt and Merrill 1950) and revised in 1963 (Watt and Merrill 1963). Table 1 of the revised publication provides calories and 16 nutrients for 2,483 foods in 100 gram portions. Additional nutrient values for some foods are also included in supplementary tables in the same volume.

Publications, such as Church and Church's (1975) "Food Values of Portions Commonly Used", contain food composition tables with items listed according to household portions. Other publications, including the USDA publications Home and Garden Bulletin No. 72, first published in 1960 (United States 1960) and most recently revised in 1971 (United States 1971); and Agriculture Handbook No. 456 (Adams 1975), provide nutrient data for foods in terms of common household measures and market units.

Since the late 1950's computer stored data bases have been compiled by the USDA (Hertzler and Hoover 1977). Presently, USDA food composition data sets are available to the public in a variety of machine readable issues. These include the data contained in the 1963 edition and 1972 revised edition of Handbook No. 8 (United States 1977a-b); the 1971 edition of Home and Garden Bulletin No. 72 (United States 1977c); and Handbook No. 456 (United States 1977d).

Additionally the USDA began compiling a Nutrient Data Bank in 1972 to serve as an international repository of nutrient data (Watt et al. 1974; Chandler and Perloff 1975; Hertzler and Hoover 1977). This facility will integrate data submitted from a variety of sources including industrial, governmental, public, and private laboratories, as well as that already stored in the USDA's Nutrient Data Research Center. In order to increase handling capacity, a computer based system has been instituted to facilitate storage, processing, and retrieval of data. The data stored in the bank will be processed in three ways. Data from individual analyses will comprise Data Base I; those from the averaged values of identical items create Data Base II; and the averaged values of similar items will form the present revised equivalent of Agriculture Handbook No. 8, Data Base III (Chandler and Perloff 1975). Provision has been made for storage of up to 215 nutrients, related constituents, and analytic values (Hertzler and Hoover 1977). Data Base II will be made available on tape for computer use. Presently, two issues of Data Base III -- those for dairy and egg products, and for spices and herbs -- are available in loose leaf format or on tape (United States 1977e).

Schaum et al. (1973) have reported on another extensive nutrient data bank. The storage space presently allotted permits expansion to a maximum of 10,000 food items with 63 nutrients each. Initially, the file contained 3,600 items, and subsequent work has increased the food item file to approximately 4,800 items (Hertzler and Hoover 1977).

In addition to the extensive compilations mentioned above, compressed tables of food composition have been developed and used by a number of authors (Leichsenring and Wilson 1951; Dawber et al. 1962; Mann et al. 1962; Browe et al. 1966) for shorthand determinations of nutrient intake. These investigators compress food item listings by foods of similar nutritive value into food groups, and establishing mean nutrient values for each group by arithmetic averages or by a weighted average adjusted to food consumption or preference practices of the population. However, these methods are better for group determinations than for individual determinations of nutrient intake, since neither the population-averaged nor arithmetically-averaged nutrient value for a food group will accurately reflect the individual's actual intake of foods in that food group (Whiting and Leverton 1960).

"The extent to which one may group food in a table depends entirely on the methodology, the nutrients one is interested in, and the amount of detail one is willing to forego for the sake of simplicity and time" (Browe et al. 1966, p. 107). In nutrition-education programs providing dietary assessments a shortened list of food items is desirable. However, compressed tables have the disadvantage that they may necessitate severe reductions in the number of nutrients assessed and the number of foods considered. Inaccurate assessment may result both from ignoring some nutrient values in order to effectively group foods, and from substituting nonequivalent food items in the condensed food list.

Pennington (1976) has produced a "Miniature Food List" and tables of nutrient composition which circumvent some of the problems usual in compressed food composition tables, by appraising the coexistence of 45 nutrients in a large number of foods. The miniature food list is composed of 202 index foods, from among those most commonly consumed in the United States, with values of 45 nutrients for each food. The index-food items can be substituted with a variety of other designated items which have been found to be similar in nutrient characteristics. The assumption used in defining substitutable items is " ... that the nutrient variation of any one nutrient in any one food (index item) is greater than the variation of all the means of that same nutrient in all the foods included in the group" (Pennington 1976, p. 9). The validity of this tool is based on the demonstrated fact that errors in dietary nutrient value due to the use of food substitution and to established serving sizes are much less than errors due to simple variation of nutrients in foods (Pennington 1976). The list does not cover all foods that are potentially available in the marketplace, but does cover a considerable number relative to the index items presented.

Pennington's miniature food list may provide an acceptable compressed table of food composition for a nutrition education system performing assessment of individual's diets. It provides a comprehensive table of food items and their nutrient values, without compromising the accuracy of the compositional values. The table provides a balance which maximizes validity of assessment but minimizes computational and data-collection difficulties.

Beyond defining the indices for dietary analysis, in this case nutrient composition, the computational method for processing dietary data should be considered. Traditionally, nutrient analysis was performed by hand calculation, however, the advent of electronic data processing offers methods for rapid and accurate nutrient analysis (Marr 1971).

Computers have been used to perform nutrient analysis on a variety of dietary data, for example, on patient food consumption records (Thomson and Tucker 1962; Brisbane 1964; Eagles et al. 1966; Beal 1967; Schaum 1973; Tuthill 1974), metabolic diets (Hjortland et al. 1966), epidemiological data (Goodloe et al. 1963; Hayes et al. 1964), and nutrition survey data (Tie et al. 1967). Calculation of menu nutrients by computer demonstrates advantages in cost (Flook and Alford 1974), accuracy, and response time over manual computation (Hoover 1976).

Computer systems offer the advantage of comprehensive analysis of nutrients and the option of complex data manipulation, for example, statistical interpretation of relationships among nutrients. Mathematical accuracy, of course, will not remove inherent errors in food composition tables. However, the computer will carry out routine calculations with speed and complete accuracy. It therefore seems advantageous to use computers when both ease and accuracy of nutrient assessment procedures would be improved.

2.3.3 Data Evaluation

The final phase of dietary assessment -- data evaluation -- requires that estimated nutrient intake be judged against appropriate standards. The dietary standard provides the present formal basis on which nutritional science and the nutrition educator define acceptable nutrient intake. Other recommendations which may supplement the values contained in the dietary standard have been proposed by recognized nutrition agencies. The following section discusses the characteristics of the standards available for appraising dietary well-being, and their suitability for evaluating individual dietary practices.

2.3.3.1 Dietary Standards

Available information on human nutrient requirements has been incorporated into dietary standards, which are, in a sense, compendia on the known nutrient requirements of man. The most recent revision of the Canadian dietary standard (Canada 1975) is defined as "a statement of the daily amounts of energy and essential nutrients considered adequate, on the basis of scientific data, to meet the physiologic needs of practically all healthy persons in a population" (p. 5). The Recommended Dietary Allowances of the United States Food and Nutrition Board (United States 1974) embodies the same principles.

Although the dietary standard is based on actual or extrapolated human requirements, the figures given are "recommended daily intakes" or "acceptable daily intakes", or as the Food and Agriculture Organization of the World Health Organization states "safe level of intakes", and not a statement of the actual nutrient requirements for each individual in the population (Passmore et al. 1974; United States 1974; Canada 1975). This distinction is very important in understanding both the design and use of the dietary standard.

Individual differences in nutrient requirements, as a result of normal biologic variability, have been considered in establishing a standard which should meet the nutrient requirements of most healthy people in the population (Beaton 1972; United States 1974; Canada 1975). Consequently, an individual whose average daily nutrient intake meets the standard for all nutrients, would have little likelihood of nutritional inadequacy. In fact, the requirement of most individuals should be less than the standard. The formulation of standards for energy intake is different. Unlike the standard for other nutrients, the recommended caloric intake approximates the predicted average requirement of the population members, instead of lying substantially above the average requirement. For this reason, there is relatively little relationship to individual requirements which may be above or below the recommended intake.

Some qualifications for the use of dietary standards are recognized. First, the dietary standards are not formulated to cover additional requirements of persons depleted by infection or injury, other traumatic stresses, prior dietary inadequacies, genetic and metabolic disorders, and the use of pharmaceutical preparations (eg. oral contraceptives); nor do they consider losses of nutrients that occur during processing and preparation of foods (United States 1974; Canada 1975). Second, although the standards are expressed as a daily average, the ability of the body to adapt to daily fluctuations in nutrient intake implies that recommended intakes do not have to be met on a daily basis (United States 1974; Canada 1975). Therefore, it is considered acceptable when estimating dietary adequacy to average weekly intake of nutrients.

Third, when using dietary standards, even accurate knowledge of actual nutrient intakes is not synonymous with evaluation of the nutritional status of eigher the individual or the population surveyed.

2.3.3.1.1 Formulation of Dietary Standards

> The ideal method, rarely if ever achieved, to develop an allowance would be to (1) determine the average requirement of a healthy and representative segment of each age group for the nutrient under consideration; (2) assess statistically the variability among the individuals within the group; and (3) calculate from this the amount by which the average requirement must be increased to meet the needs of nearly all healthy individuals (United States 1975, p. 5).

Insofar as possible, the above methodology is followed for developing a nutrient allowance. Population groupings are selected for many of the major identifiable factors influencing requirements -- that is, age, sex, body size, physiological state, and physical activity (Harper 1974; United States 1974). Utilizing available estimates of average requirements and variability within the populations studies, allowances for nutrients other than energy (which is an estimate of average needs of the group), are developed by increasing the average nutrient requirement two standard deviations (Lorstad 1971; Beaton 1972; Harper 1974; United States 1974). Providing or assuming that individual requirements fit a statistically normal distribution, an allowance set two standard deviations above average should be sufficient to meet or exceed the needs of 97.5% of the individuals in the population (Lorstad 1971; Beaton 1972). Unfortunately, such allowances cannot be established for most nutrients, with the exception of thiamin, riboflavin, niacin, iron, and protein, because there is inadequate information about the variability of individual requirements (Beaton 1972).

When information on the requirements of large groups of individuals is not available, average requirement and estimated variability are derived from the following data: one or two controlled feeding trials on a limited number of subjects; critical metabolic studies on animals with values extrapolated to man (the translation is fraught with undertainty); or dietary surveys on the minimum amount of a nutrient known to be consumed by apparently healthy people (Harper 1974; United States 1974; Canada 1975). Unfortunately, the basic requirement and figures for assumed or actual population variability from which the allowances have been derived are not stated in the dietary standards (Lorstad 1971).

Factors that influence the efficiency of nutrient utilization are considered in setting allowances. These include precursor conversion ratios, efficiency of absorption, digestibility, assimilability, and utilization of complex nutrients like protein (Young 1964; Jelliffe 1973; Harper 1974; United States 1974). The importance of each of these factors differs from nutrient to nutrient, so the extent to which the allowance for different nutrients must exceed requirements varies accordingly.

Although the methodology for establishing allowances is generally accepted, estimates of nutrient requirements arrived at by committees represent the results of accommodation and judgement. Consequently, recommendations from different committees may differ (Goodhart 1973; Harper 1974; Canada 1975).

2.3.3.1.2 Use and Interpretation of Dietary Standards

Dietary standards have come to serve as guides in an expanding number of areas. However, "there are two primary uses of dietary standards -- to serve as guides for the planning of diets and food supplies and to evaluate nutritional adequacy from food consumption data" (Hegsted 1975, p. 13). With respect to both uses, publications of dietary standards have regularly indicated that the values are intended for use as guides applicable to populations and large groups, and that they are not intended for application to the individual. Additionally, as mentioned, dietary standards cannot be used by themselves for the assessment of nutritional status of either individuals or population groups (Goodhart 1973).

Although the limitations on the use of dietary standards have been published repeatedly, Beaton (1972) indicates, " ... the meaning and interpretation of the figures remains a matter of doubt, confusion, and often argument" (p. 356). For example, there is a " ... dichotomy represented by the Food and Nutrition Board's insistence that they were intended for use only when dealing with groups of people, but at the same time, the Board's willingness to give, in the 1974 edition, individual figures for twenty-four age-sex groups plus those for pregnancy and lactation" (Leverton 1975, p. 9). It appears as suggested by Beaton (1972) " ... the recommendations are based upon a consideration of the individual, not population requirements -- or rather, upon a consideration of individual requirements within a population" (p. 356). Referring to the Recommended Dietary Allowance of the Food and Nutrition Board, Hegsted (1975) has further criticized the utility of one standard for two purposes -- evaluation and planning of diets -- and suggests that neither purpose is fulfilled with the present standard.

The dispute over whether the standards are appropriate for use with populations and not for individuals is of particular importance to nutrition educators. The warnings provided in the dietary standard, about their use for evaluating or planning individual's diets, although instructive, fail to address the needs of nutritional practitioners who must evaluate and plan individual's diets (Hegsted 1975). Beaton (1972; 1975) and Lorstad (1971) have been instrumental in the development of a logical approach to the interpretation of nutrient intake data for both populations and individuals. Their approach, discussed below, recognizes that population data defining dietary standards are in fact data on a population of individuals. The dietary standards so derived can be used rightfully to evaluate and plan the diets of individuals.

The objective of a dietary study is to determine whether deficiency exists in the individual, or in the case of a population, the proportion of the population that is deficient. The problem posed then is: what interpretation should be placed on those individuals with intakes below the recommended level, and for the population as a whole, what prevalence of deficiency might be expected (Beaton 1972; Beaton 1975)? The Canadian (Canada 1975) and American dietary standards (United States 1974) have clearly indicated that the intake of a person habitually consuming nutrients below the recommended levels cannot be interpreted as an inadequate intake for those nutrients.

The method proposed by Beaton (1972; 1975) is, in short that, providing data are available to describe the distribution of individual requirements in a population, then, by the application of probability statistics it is possible to determine the risk or probability of deficiency to an individual, or the prevalence of deficiency in a population. As Beaton (1975) suggests,

" ... assessment of the adequacy of nutrient intake should be based upon a judgement of the probability or risk of deficiency rather than on an 'adequate' or 'inadequate' basis ..." (p. 31). Whether the individual's diet is adequate will depend on where the individual's true requirement lies in relation to the assigned requirement, and this is not known. Similarly, population averages of nutrient intakes can be compared to the recommended allowance, but a population that fails to meet the standard does not necessarily have inadequate diets (Hegsted 1975). Thus, it is only within the framework of probability that the dietary standard can be used legitimately and meaningfully to interpret the relationship of nutrient requirement and the individual's nutrient intake (Beaton 1972; United States 1974; Beaton 1975) or the population's nutrient intake (Beaton 1972; Beaton 1975).

The concept outlined by Beaton (1972) will be summarized below. In order to determine individual risk of deficiency, a knowledge of the distribution of the individual requirements in the population is needed. This is illustrated below in Figure 2.1 with the assumption of a normal distribution about the mean requirement. The recommended intake lies at two standard deviations above the mean, a level which should meet or exceed the requirements of 97.5% of the individuals in the population.

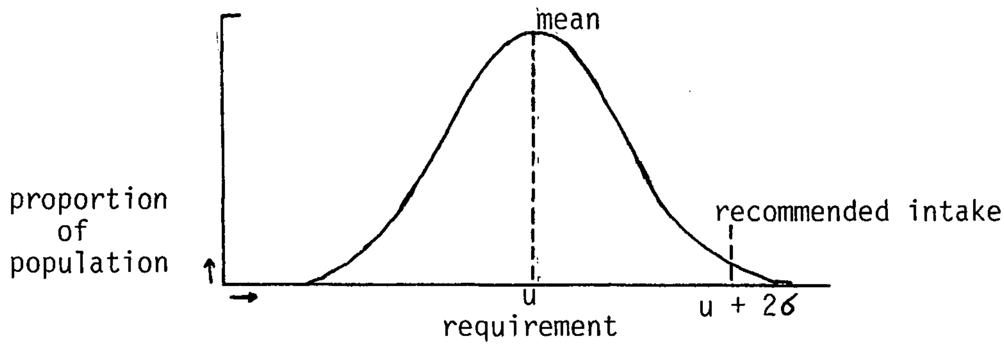

Figure 2.1 Individual variability in nutrient requirements (Beaton 1975).

Utilizing the data on the variability of nutrient requirements in the population (Figure 2.1), a cumulative distribution can be developed to (Figure 2.2) describe the proportion of the population with requirements above a certain intake level. This curve corresponds to a distribution of probability or risk of deficiency for an individual at any given intake level, and provides a basis for interpretation of individual nutrient intakes.

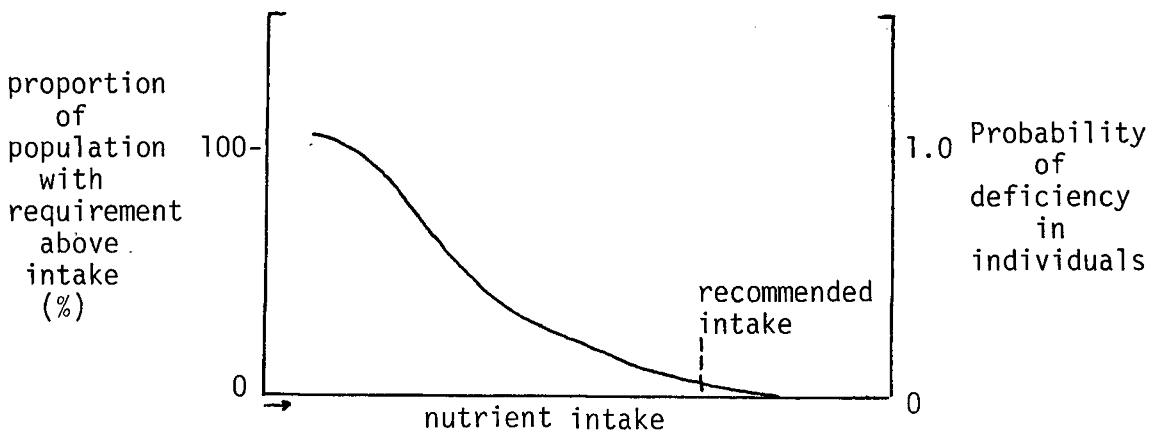

Figure 2.2 Proportion of the population having actual requirements above nutrient intake and the probability of deficiency in individuals ingesting a particular level of nutrients (Beaton 1975).

Beaton (1972) derives a first principle for use in interpreting individual and population nutrient intake data from the above graph (Figure 2.2). The principle states " ... an individual habitually consuming the recommended intake (or more) of a nutrient must be considered to be at low risk of deficiency. As ... intake falls, the risk of deficiency increases" (Beaton 1972, p. 358), in a manner predictable from a knowledge of the distribution of requirements. Thus, although it is not known whether an individual intake is inadequate, the individual's dietary intake can be interpreted in terms of the risk of deficiency associated with that intake.

This concept can also be applied to populations to predict the prevalence of deficiency in a population. For this purpose Beaton (1972) derives a second principle. The second principle states, " ... when population data are considered, it is necessary to consider both the variability of nutrient requirements among individuals and the variability of habitual intake among individuals" (Beaton 1972, p. 358), before the prevalence of deficiency can be meaningfully determined. The variability of both requirement and intake must be considered since the ratios of these variabilities will influence the prevalence of predicted deficiency as illustrated in Figure 2.3 below. A consideration of the average intake of a population alone will not provide a measure of prevalence of deficiency. In this respect Beaton (1972) derives a third principle which states, " ... an observation that the average intake of a population group is at or above the recommended intake does not mean that all individuals are well nourished" (p. 359).

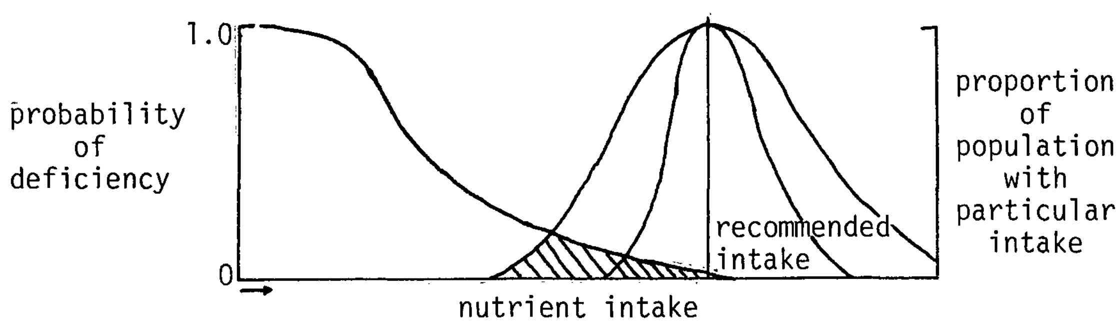

Figure 2.3 Theoretical model of the relationship of the nutrient intake of a population to the prevalence of deficiency (Beaton 1972).

Thus, the dietary intake of an individual cannot rightfully be deemed adequate or inadequate on the basis of a comparison with the dietary standard, since it in not known where the individuals true requirement lies in relation to the standard. However, it has been customary to make such assignments. Similarly, nutritional adequacy is not assured if the average intake of a population meets the standards. The prevalence of deficiency will depend on the range of individual requirements and intakes within the population. Therefore statements about population groups such as, " ... 'The average intake meets RDA standards; therefore, there is no problem of nutritional inadequacy.' are ... invalid" (United States 1974, p. 14). Also statements such as the " ... 'RDA includes a large safely factor; therefore a diet that meets two-thirds of the RDA standard should be adequate', have no validity" (United States 1974, p. 14). A nutrient intake of two-thirds of the dietary standard will be adequate for some but inadequate for others; there is no way of knowing who falls into which category. However, providing the distribution of requirements is known the risk of deficiency at this level can be computed.

Unfortunately, the distribution of requirements is not available for most nutrients for which requirements are established. In these cases, requirements are established by committee judgement to include an estimate of population variability. Whether true or estimated variability is used, it would still seem desirable to utilize Beaton's concept of risk so that an individual habitually consuming the recommended intake, or more, must be considered to be at low risk of deficiency. As intake falls, the risk of deficiency increases. Since individual requirements are not known, the individual's intake can be interpreted in terms of the risk of deficiency associated with a particular intake. Depending on the available data on population variability, this interpretation can be performed either with high numerical accuracy, or alternatively, simply as an indication of a trend towards greater or lesser risk.

2.3.3.1.3 Limitations of Dietary Standards

Even if the nutrient content of the daily food ration meets the dietary standard, there are several reasons why this is insufficient information to formulate an ideal, or adequate, or low risk diet. Dietary values should be applied with recognition of the following limitations.

Present knowledge of nutritional needs is incomplete. Nutrient needs as yet undiscovered may still exist. For this reason the Bureau of Nutritional Sciences in their publication "Dietary Standards for Canada " (Canada 1975) suggests, " ... recommended intakes should be achieved by eating a variety of foods because unknown nutrients may be present which are essential for the maintenance of health' (p. 7). Similar qualifications are forwarded in the American standards. However, this is not completely consistent with the indication in the same volumes, that standards are acceptable for use as guidelines in processing and fabrication of foods (Hegsted 1975; Leverton 1975).

Requirements for many nutrients recognized as essential have not been established (Harper 1974; United States 1974), and for those that have, the requirements are based on a criteria of deficiency rather than a nutrient optimum (Mertz 1972). Since requirements are based primarily on knowledge of deficiency states, they do not differentiate long-term nutrient consequences other than some conditions of deficiency. Further, safe maximal levels of nutrients have not been established.

Many possible factors which may significantly influence requirements in individuals have not been established. For example, standards do not explicitly consider: drug-nutrient interactions, such as oral contraceptives; nutrient-nutrient interactions, such as the effect of vitamin-D on calcium retention, protein intake and the vitamin-B6 requirement, and amino acid balance with protein requirement; the effect with noxious chemicals; individual sensitivity to nutrients; diurnal rhythms; diet pattern; nutrient history; climatic conditions; and the effect of a potentially large number of environmental factors. As " ... a source of nutrients, food has psychological and social values that are difficult to quantify" (United States 1975, p. 2), these psychological vectors of nutrient requirements have not been considered explicitly in defining the present standard. Other factors important in determining the dietary requirements of individuals include: the organism's ability to adapt to its environment, and the aspirations of the individual and the expectations that society has for the individual. Factors, such as those above, must be considered in defining human nutrient requirements, however, there is still lack of knowledge concerning the factors that effect nutrient requirements in individuals. (Goodhart and Shils 1973; United States 1974; Canada 1975).

Additionally, for many nutrients for which requirements have been identified, there exists considerable conflict in their formulation (Harper 1974). For example, Hegsted (1967) points out that,

> although most of the people of the world do not consume enough calcium to meet the dietary recommendations, and thus are often said to be calcium deficient, there is no convincing evidence that this is true. We do not even know what calcium deficiency looks like in man" (p. 107).

It is uncertain whether criteria to determine requirements in adults should be set to maintain body weight, or prevent nutrient depletion as indicated by balance studies, tissue concentrations, specific functions, or specific deficiency signs (Harper 1974). Note that "for some nutrients there is a considerable difference between the amount that will prevent the development of specific signs of deficiency and the amount required to maintain maximum body stores" (Canada 1975, p. 6). Additional criteria that may be useful in determining requirements, such as sleeping pattern and wound healing time, have been proposed (Davis and Williams 1976). Further, data used in estimates of requirements are often fragmentary and based on limited experimental data on humans (Canada 1975), or in fact may be extrapolated from animal studies (Hegsted 1975).

2.3.3.2 Further Dietary Recommendations

2.3.3.2.1 Recommendations for Nutrients Not in the Dietary Standard

The recent Canadian dietary survey (Canada 1973) indicates that some nutritional problems exist in the Canadian population with respect to nutrients for which the "Dietary Standard for Canada" (Canada 1975) has established requirements. However, vital statistics (Canada 1976b) report negligible mortality in the Canadian population from diseases associated with these nutrients.

Although the "classic" nutritional deficiency diseases appear to be of minimal public health significance in Canada, dietary components have been implicated as etiologic factors in diseases which are among the major causes of death in Canada. These diseases include, most notably, cardiovascular disease (ischaemic heart disease and cerebrovascular disease) and cancer of the gastro-intestinal tract (Lalonde 1974). Diabetes mellitus also ranks as a significant cause of mortality (Canada 1973). Additionally, these aforementioned diseases have importance for population morbidity figures, as do the diet related problems of dental caries, periodontal disease, obesity, and alcoholism.

Whereas the dietary standard provides figures for the nutrients associated with the diet-related diseases of low mortality, appropriate standards are not included for the dietary components and nutrients associated with the high-mortality diseases. However, recommendations and guidelines for these nutrients and food components, which may be used to supplement the dietary standards, are available from recognized nutritional agencies.

The American Heart Association (1973), Canadian Committee on Diet and Cardiovascular Disease (Canada 1976a), and Senate Select Committee on Nutrition and Human Needs (United States 1977f) provide recommendations for the dietary intake of fats and salt. These are proposed primarily because of their implication in the etiology of cardiovascular disease. To reiterate briefly, the suggestion by these agencies is for a reduction in consumption of fat. Reduction in saturated fat with a proportionate increase in poly- and mono-unsaturated fat intake is also recommended. The American recommendations (American Heart Association 1973; United States 1977f) also suggest limiting cholesterol intake. Lower intake of salt is recommended by these agencies since excess dietary sodium is considered an adverse factor in some people prone to hypertension (Meneely and Battarbee 1976). However, in accepting these recommendations, it should be appreciated that the diet-heart hypothesis has not stood uncriticized (Werko 1976; Mann 1977). Also, the goals of the Senate Select Committee on Nutrition and Human Needs have been both supported (Latham and Stephenson 1977) and criticized (Harper 1977) in recent publications.

The Senate Select Committee on Nutrition and Human Needs also presents guidelines for total and simple carbohydrate composition of the diet. Additionally, the Bureau of Nutritional Science of Canada (Cheney 1976) is developing guidelines for meal replacements which provide values for dietary fibre. Decreased dietary fibre intake has been implicated with increased incidence of gastro-intestinal cancer and other gastro-intestinal disorders (Burkitt and Painter 1974; Spiller and Amen 1975); and with coronary heart disease (Klevay 1974).

Although dietary recommendations which are based primarily on epidemiological data, such as those from the American Heart Association (1973), may be less precise than those derived from metabolic studies, the potential public health significance of these recommendations may justify, or in fact necessitate, their inclusion in the formulation of prudent nutrition education programs. The implication is that the contribution to the total risk of mortality and morbidity from the secondary nutritional component of the high incidence diseases in North America is as substantial, if not greater, than the mortality and morbidity due to nutritional diseases where diet is the primary agent. Unfortunately, recommendations in this area are highly controvertial and therefore difficult to interpret.

2.3.3.2.2 Recommendations for Maximum Intakes

The Canadian dietary standard (1975) suggests that " ... a consideration of possible effects from intakes far in excess of estimated nutrient requirements is outside the scope of present standards" (p. 7). Similarly the American standards (United States 1974) and those of the World Health Organization (Passmore et al. 1974) do not explicitly consider upper levels on nutrient intakes. Whereas the recommended values presented by the dietary standards are minimum suggested levels of intake, with the exception of calories, many of those discussed directly above correspond to maximum recommended levels of intake.

Although quantities in excess of requirements for individual nutrients have been proposed as beneficial (Pauling 1976), the Food and Nutrition Board (United States 1974) suggests that:

> ... we are aware of no convincing evidence of unique health benefits accruing from consumption of a large excess of any one nutrient. Large doses of individual nutrients may have some pharmacological action, but such effects are unrelated to nutritional function. Claims that large intakes of individual nutrients will cure non-nutritive diseases should be viewed with skepticism ... (p.3).

No specific benefits or disadvantages are recognized from the ingestion of excessive quantities of many nutrients. However, toxic ceilings have been identified for some nutrients (Goodhart and Shils 1973).

In a program designed to monitor nutrient intakes, if possible, assessment should explicitly articulate an acceptable range of intake -- that is, both maximum and minimum nutrient limits should be stated. When using standards it is suggested (United States 1974) that intakes substantially above requirements are not harmful. However, these amounts are not specified. Ignoring values above the requirements established in dietary standards, in light of the availability of high-potency nutrient supplements and extensive food fortification, may be unwise. The necessity of setting minimum and maximum values for nutrients in new products is advised in the American Recommended Dietary Allowance (United States 1974).

2.3.3.3 Conclusions

Standards against which individual nutrient intake can be judged are available both from publications of dietary standards and from the recommendations proposed by recognized nutrition agencies. The standards are not absolute limits which separate good from poor diets, but rather are guidelines or goals which indicate the likelihood or probability that a diet is adequate for an individual. The standards may be used meaningfully to provide guidelines for individual and population dietary practices.

When dealing with total populations, a particular prevalance of deficiency can be set as the public health objective -- that is, a certain risk to the population. When intake variability in the population is high, and therefore per-capita nutrient increases needed to reduce the prevalance of deficiency would be unreasonable, then the public health effort would be to selectively identify those persons with low intakes and raise their intakes. Since actual requirement and consequently true risk are not known, the usual approach in counselling individuals is to urge consumption of sufficient nutrients to achieve the dietary standard, which corresponds to a low level of risk. Both the individual counselling and the national planning approach can be defended as proper public health objectives. In using the dietary standard, a public health or statistical concept is used rather than a clinical or therapeutic one (Clements 1975: Latham and Stephenson 1977).

In many cases these standards or goals are not well accepted. However, the importance of accepting some uncertainty in developing standards is emphasized by Latham and Stephenson (1977), who, in discussing the nutrition-education profession's responsibility for establishing goals, state:

> Worrying to us is the use by the opposition of the argument that we lack information to set goals at all. That surely is an abrogation of responsibility, a "cop-out". There will always be uncertainties and more research that needs to be done. But advice has to be given, ... Goals need to be set ... (p. 152).

Further the results of evaluation should not be erroneously extrapolated into a judgement about the nutritional status of the individual. Although there is little virtue in assigning interpretations to dietary data that cannot possibly be valid, one cannot deprecate the value of dietary data as an indication of potential nutritional status. Evaluation of dietary data can be utilized as an effective public health tool to provide assessment of food selection practices of individuals -- and in fact may be the only practical method presently available to do so.

2.4 Dietary Prescription

2.4.1 Diet Planning

Conventional methods (Ohlson 1972) of planning human diets for out-patient diet counselling, or for modifying pre-assessed hospital routines, include: generalized and simplified models for assessing dietary adequacy, such as food guides, concepts of dietary variety, the prudent diet, and checks on a limited number of nutrient values; computational aides, such as exchange lists; and a variety of rules of thumb and trial-and-error procedures. The above methods help to simplify the inordinately complex procedure of dietary assessment and prescription. However, these methods do not make explicit use of all the information necessary to provide precise conclusions in the planning of human diets (Gelpi _et al_. 1972; Balintfy 1973a; Head _et al_. 1973). This problem becomes particularly evident as the complexity of a diet problem increases, or alternatively, as the constraints on an acceptable solution become more severe.

Human diet problems are amenable to mathematical definition, formulation, and solution (Balintfy 1973b; Balintfy 1976a), and in fact may require mathematical modelling for effective resolution (Balintfy 1973a). Balintfy (1973a) indicates that " ... the problem of diet planning is not a nutritional, but a mathematical one ... [which] ... defies definition, both conceptually and operationally, unless the problem is cast into some mathematical model ..." (p. 581). Therefore, it would seem important that realistic mathematical formulations be available for human diet problems.

Without mathematical techniques, nutritionists have limited use for the potentially extensive information required to ensure that nutrient adequacy, preference, production requirements, and budgetary restraints are met when planning diets -- " ... more data means only that more information will have to be ignored" (Balintfy 1973a, p. 581). Consequently, conventional procedures exhibit suboptimal decision processes as compared to mathematical programs (Balintfy 1976b). For example, menu planning models, utilizing mathematical programming techniques designed to optimize costs, have demonstrated raw food cost savings of 5 to 34 percent and improved nutritive control without sacrificing patient satisfaction, as compared to conventional planning techniques (Gelpi et al. 1972; Balintfy 1975).

Additionally, increased technical demands on dietitians necessitate the use of tools which improve efficiency. Computerized mathematical programs for diet planning provide dietitians with data, and techniques for data manipulation, which would otherwise be impracticable. Also, there is some indication that the demand for nutrition services may outstrip available manpower committments unless supplemented by technological means (Witschi et al. 1976).

Food selection or diet planning problems can be modelled mathematically as constrained optimization problems (Balintfy 1976a). As such, the planning of human diets is a decision process to assure satisfaction of a number of simultaneous requirements. These requirements are certain attributes of food and food intake, such as food cost, nutritive value, palatability, and production characteristics (Gelpi et al. 1972). Although any suitable set of optimization objectives and constraints may be defined for diet planning, typically coefficients of food cost have been optimized within constraints established by nutritive specifications and palatability (Smith 1963; Balintfy 1976a). Recently, considerable exploration has been undertaken of models which optimize measures of food preference (Balintfy 1976a).

Human diet problems, according to Balintfy (1973b), fall into two major categories; food planning and meal planning. Food planning is concerned with decisions of food allotment, over an undifferentiated but specified time period, which characteristically must meet given budgetary, nutritional, and acceptability requirements. Alternatively, meal or menu planning is concerned with a temporally-defined food-allotment decision. Meal planning defines " ... an optimum sequence of meals consisting of combinations of prepared foods, called menu items, ... such that the required structure of meals and given budgetary, nutritional, and food production specifications are met" (Balintfy 1973b, p. 1). As discussed below, a number of approaches to defining, formulating, and solving human diet problems by mathematical means have been undertaken.

2.4.1.1 Food Planning Models

2.4.1.1.1 Food Planning Without Palatability Considerations

Early food planning models were designed to find "minimum-cost" combinations of foods which met specified nutritional standards. These purely nutritional models were formulated to find the lowest cost of physiological subsistence and not to consider elements of dietary palatability or acceptability such as: variety, prestige, or other cultural and personal concerns (Smith 1963).

In order to optimize food costs within a prescribed nutrient allowance three types of data are required: a list of nutritional requirements, the nutrient composition of available foods, and price coefficients for each food item. A formal statement, in algebraic notation, of the essential relationships between the optimization objective and the three kinds of information used in the construction of least-cost diet models is as follows:

> Let z be the total expenditure, n the number of foods, p_j the unit price of commodity j, x_j the quantity of commodity j to be consumed, m the number of nutritional requirements (restraints), b_j the quantitative requirement set by the i^{th} restraint, and a_{ij} the quantity of nutrient i contained in one unit of commodity j. In this notation, the problem is to
>
> $$\text{minimize } z = \sum_{j=1}^{n} p_j x_j$$
>
> $$\text{subject to (1) } x_j \geqslant 0 \qquad (j = 1, 2, 3, \ldots, n)$$
>
> $$\text{(2) } \sum_{j=1}^{n} a_{ij} x_j \geqslant b_i \qquad (i = 1, 2, 3, \ldots, m)$$
>
> That is, z, the total expenditure on foods purchased, is the sum of the expenditures on each food, where $p_j x_j$ is the expenditure on the j^{th} food. The quantity z is to be made as small as possible, subject to the two requirements that (1) no negative quantities of foods may be purchased and (2) the total quantity of the i^{th} nutrient (the sum of the quantities, $a_{ij}x_j$, provided by each food) shall equal or exceed the required amount, b_i, for each of the m nutrients (Smith 1963, pp. 6-7).

As indicated by Smith (1963), the earliest formulations of the minimum-cost diet problem were by Cornfield (1951) in 1941 and by Stigler (1945) in 1945. Although both authors developed solutions, Cornfield's was proposed for the case of two foods with any number of nutritional restraints (Dorfman et al. 1958; Smith 1963). Stigler provided the first solution for a general problem with nine equations of nutrient requirements and seventy-seven unknowns for the amounts of food items in the diet (Danzig 1963; Smith 1963). Stigler's solution was not obtained by linear programming but by a systematic procedure of trial and error. Consequently, he could not be certain that an optimal solution had been obtained, although he believed that his result was close to the optimum (Smith 1963).

Linear programming of human diets, and in fact linear programming in general, was not available until Dantzig and Laderman offered a general method of solution to the least cost diet problem, called the Simplex Method, in an unpublished paper written in 1947 (Dorfman et al. 1958; Dantzig 1963). Thus, Dantzig's discovery of the Simplex method of linear programming allowed for realistic solutions of an econometric problem previously only solvable in principle.

The solutions obtained by Stigler (1945) and in 1947 by Dantzig and Laderman (Dantzig 1963) appear in Table 1. The recalculated solution to Stigler's problem by Dantzig and Laderman, used Stigler's August 1939 price index data, his food composition data for seventy-seven items, and his nine nutrient allowances. This linear programming solution produced an annual subsistence diet with beef liver instead of evaporated milk, and required that the proportions of other items change. However, just as Stigler believed, his solution was close to the true least-cost diet -- within 25 cents per annum. In fact, Stigler's answer was only one iteration from the optimum (Vajda 1958).

Table 2.1 Annual subsistence diet for a moderately active adult male, calculated using linear programming methods.*

Commodity	Stigler solution amount (lb.)	Stigler solution cost+ ($)	Dantzig-Laderman solution amount (lb.)	Dantzig-Laderman solution cost+ ($)
Wheat flour (enriched)	370	13.33	299	10.77
Evaporated milk	57 cans	3.84		
Cabbage	111	4.11	111	4.11
Spinach	23	1.85	23	1.85
Dried navy beans	285	16.80	380	22.28
Beef liver			2.4	.69
total annual expense...		39.93		39.68

* Calculated by Stigler (1945) and recalculated by Dantzig and Laderman (Dantzig 1963)

+ Cost determined using Stigler's August 1939 price index data.

Food planning models using linear programming have been developed by other authors including Vajda (1958), Beckman (1960), and Smith (1963). These models provide solutions of minimum cost diets which meet from 3 to 13 nutrient restrictions, and consider a commodity list of from 8 to 73 food items. Since linear models usually provide solutions with fewer foods than restrictions, the diets obtained from these models contain a predictably small number of food items. Beckman's solution contains 4 foods, Vajda's solution 3 foods, and Smith's midget model solution 6 foods. Smith (1963) indicates that neither Vajda's model nor his own model can be considered.atrue least-cost subsistence model since the food list used was chosen with consideration of each item's palatability. Lower-cost, unpalatable items may not have been included in the calculations. The food list used obviously effects the character of the solution obtained.

A recent reflection on the low-cost diet, called the "three-consideration diet" (for the three statements of nutrient allowance, food composition, and food prices), has been introduced by Lewis and Peng (1977). Daily diets were computed for each member of a four-person reference family using the 1974 U. S. Recommended Dietary Allowances, current food composition data, and Bureau of Labour retail price statistics for Atlanta, October 1975. The authors indicate that the diets produced are less than satisfactory with respect to variety and palatability, although they are somewhat more varied than earlier models. The additional nutrient constraints, 17 altogether, have resulted in diets of 7 or 8 items which includes vegetable oils and grain products in addition to other food groups. In comparison Stigler's solution contained no animal fat or vegetable oil, and the Beckman diet did not contain grain products.

Some authors have focused on the application of linear programmed least-cost diet problems for field conditions rather than for illustrating the mathematics of linear programming. Florencio and Smith (1969; 1970) have utilized least-cost diet methods to measure the efficiency of food purchasing among working-class families in Columbia. Efficiency was determined by an index which compared the cost of actual foods consumed with a mathematically optimized least-cost diet which was developed from commonly consumed foods. Least-cost models have also been used by Chamberlain and Stickney (1973) and Kansra et al. (1974) for development of least-cost nutritionally balanced multimixes suitable for children in developing countries.

All of the models presented above, and other diet models to be presented below, utilize linear nutrient constraints which are specified in absolute amounts, or where nutrient interdependencies exist, as fixed ratios or exact constants. Smith (1974) has developed a food planning model which modifies the standard formulation of dietary constraints by the introduction of nonlinear constraints for determining protein allowances. The model considers simultaneously the effect of both protein concentration and protein composition on protein allowance in determining the most economical diet which satisfies protein needs and other nutrient requirements. Utilizing the nonlinear protein constraint provides an opportunity to economize by consuming smaller quantities of higher quality protein or larger quantities of lower quality protein while meeting protein requirements. The problem is solved using separable programming to obtain linear approximations to nonlinear restraints.

Smith's (1974) model was designed for national food planning problems where efficient use of protein resources is required, for example in the developing countries, Carmel (1976) has developed a model of similar nature and application using the concept of ND_pCal percent to account for the relationships between energy content, protein quantity, protein quality, and protein value of diets. Diet planning with variable nutrient coefficients has been discussed by Armstrong and Balintfy (1975).

2.4.1.1.2 Food Planning Models with Palatability Considerations

Comparison of the results of purely nutritional models with low-cost diets prepared by nutritionists illustrates discrepancies in dietary cost and composition due to factors beyond those explicitly considered in the modelled diets (Smith 1963). As Calavan (1976) states:

> The solution to this prescriptive food selection model typically consists of an unpalatable, boring combination of three to seven food items. Except for populations on the verge of starvation, such solutions are optimum only in an arbitrary mathematical sense (pp. 65-66).

Consequently, many later diet models have included explicit statements of palatability in their formulations, in attempts to produce diets which are more congruent with actual consumption patterns. Both linear and non-linear models have been developed.

In an early example of formulations considering palatability, Brown (1954) attempted to develop a descriptive programming model which would produce a diet for one person similar to the actual diet of the British working class. As Calavan (1976) indicates, this objective was different from that of prescriptive models which attempt to define nutritionally adequate diets.

Three initial models tested by Brown were similar to the nutritional models which have been previously discussed. In these models prediction of consumer behaviour was based on the hypothesis that the consumer's objective was to select the least-cost diet which met specified minima of twelve food composition factors. These factors corresponded to nutrient restraints established by population practices and not to physiological requirements identified in dietary standards. The computed diets were derived from a basic list of 15 food groups averaged for price and nutrient composition. The solutions obtained consisted of from five to eight groups for the fifteen food groups. Not unexpectedly, Brown found that as more nutrient restraints are included, the diet becomes more varied and more expensive.

In Brown's fourth model an additional objective of consumer behaviour was included. This was an explicit restraint on the levels of bread and potatoes consumed. Brown's most sophisticated model provides a weekly diet for one person which includes eight of the fifteen groups consumed by the population. He judged the fourth model as adequate because it selected foods in all the major groups used by the population, except fruit, and because the calculated weekly expenditure is only about twelve percent lower than actual population expenditures.

The major difference between the formulation of Brown's models and earlier nutrition models is the use of quantity restraints on some items. This concept has been further extended by Smith (1963). Smith has developed three food planning models beyond the midget model which was previously discussed (p. 85). These are; the midget model with cooking aids, the small model, and the large model. These models utilize an objective function of cost minimization, and explicit palatability constraints designed to provide solutions which conform to conventional consumption patterns.

Smith's most sophisticated model, the large model, provides an inexpensive, nutritious, and reasonable palatable diet of 62 items for a family of three over a four week period. Unlike the other Smith models (and those of Stigler, Beckman, Vajda, and Brown) which have a limited number of food classes, the large model utilizes an expanded commodity list of 572 widely consumed individual food items and narrow commodity classes.

In the large model, item acceptability and dietary variety depends primarily on the use of a large number of constraints on the amounts and associations of foods included in the diet, rather than on a restricted commodity list as in earlier models. In fact many of the items in the expanded commodity list are unpalatable raw materials or ingredients which become acceptable only by their association with other ingredients in the diet.

The 85 commodity constraints used in the large model include ten complimentary constraints which define proportionalities among different items, 28 maximum quantity and 41 minimum quantity limits on the consumption of certain foods, and six requirements for specified amounts of some commodities. Only the large model uses all four types of commodity restraints. Additionally, thirteen nutritional restraints are defined. Twelve identify minimum acceptable intakes while the thirteenth provides a maximum total caloric intake for the diet. Thus, a total of 98 restraints have been defined in the large model.

The commodity constraints protect against excessive amounts of some items, and against exclusion of important items which are common in the usual diet or which are required to make some ingredients palatable. The constraints are in most cases based on exact or adjusted figures derived from the consumption patterns of populations, although in some cases arbitrary or experimental values are incorporated.

Calavan (1976) used a linear programming approach to develop a descriptive model of food selection practice which would be appropriate for research on the epidemiology of malnutrition. Data on the socio-economic variation of food-use practice in a northern Thai village was used to identify indices or goals around which the residents optimized dietary behavior. The identified goals of the population were to satisfy energy requirements, maximize dietary variety, maximize intake of animal foods, and maximize fat intake. A tentative model was constructed utilizing a series of linear programs which, while staying within budgetary limits, selected foods to satisfy a specified sequency of the above householder dietary goals.

Comparison of model-generated and household-generated food lists was the intended evaluative format, however, insufficient data were available for field testing. Instead, less conclusive tests of comparison indicated that the goals adopted in the original model were consistent with population data on socio-economic variations in dietary behaviour, provided the sequency of these goals was slightly modified.

Various nonlinear food models have been developed. The Consumer and Food Economics Division of the U. S. Department of Agriculture has developed a nonlinear programming model to aid in adjusting their family food plans to coordinate with food price fluctuations, changes in established nutrient allowances, and changes in eating habits of the population (Balintfy 1976a).

The model provides an adjusted food plan which is nutritionally adequate and which approximates food-group consumption patterns for each of 22 sex-age groups and income levels established by the 1965-66 Household Food Consumption Survey. The precise formulation is as follows;

> Let q_i denote the past consumption of food quantity i and x_i the corresponding quantity in the new food plan. The optimal food plan is thus formulated as the following quadratic programming model:
>
> $$\text{minimize} \sum_{i=1}^{n} w_i^2 (q_i - x_i)^2 ,$$
>
> $$\text{subject to } Ax \geqslant b,$$
> $$Rx \geqslant d,$$
>
> where w_i are weights to equalize the relative contributions of deviations, and where A is the matrix of food cost and nutrient composition data for up to 17 food groups and 18 nutrients per group. The R matrix represents a set or upper and lower bounds as well as proportionality constraints imposed on the components of the solution vector to assure strictly positive and acceptable food quantities Balintfy 1976a, p. 328).

In 1958 Wolfe developed a nonlinear food planning model which reduces dietary monotony while ensuring economy (Smith 1963). The model incorporates a quadratic index of disutility or "fatigue" in the ojbective function which is based on the assumption that excessive consumption of any food would cause disutility proportional to the square of the quantity consumed. The quadratic expression ensures a disproportionately large penalty at higher levels of consumption for any item and therefore limits the total intake of any item.

Wolfe's model is formulated as follows:

Let n be the number of foods, p_j the unit price of commodity j, x_j the quantity of commodity j to be consumed, m the number of restraints in the model, b_i the quantitative requirement set by the i^{th} restraint, a_{ij} the quantity of nutrient i contained in one unit of commodity j, and f_j the "fatigue" or disutility function for the j^{th} food. Minimize z for all of the arbitrary numbers P between 0 and 6.8077, where

$$z = P \sum_{j=1}^{n} p_j x_j + \sum_{j=1}^{n} f_j x_j^2 \qquad (j = 1, 2, 3, \ldots, n)$$

subject to (1) $x_j \geqslant 0$

$$(2) \quad \sum_{j=1}^{n} a_{ij} x_j \geqslant b_i \qquad (i = 1, 2, 3, \ldots, m)$$ (Smith 1963, p. 30)

In the above equation, P is an arbitrary weighting factor which determines the emphasis to be given to dietary economy. At P = 0 there is no cost consideration, whereas at P = 6.8077 cost considerations are dominant as in the classical cost minimization linear solution. z is the total of the weighted cost of the diet plus the index of disutility.

To test the model Wolfe used data from the Stigler model for the nutrient requirements and for cost and nutrient coefficients. Only twenty items from Stigler food list were used. Wolfe found that as the emphasis on economy was decreased, the solution developed from the basic Stigler solution of five items to incorporate all twenty items available in the abridged food list. The cost of the diet rose accordingly.

In a further nonlinear example, Balintfy (1976a) discusses a model, called the "weightwatcher's quadratic diet model", which contains a nonlinear objective function in its formulation. The model functions to maximize the total dietary utility or "preference" while meeting cost and caloric constraints. The program uses data on the estimated quadratic utility functions for sixteen food groups, and on the cost and caloric content of each food group. Nutrient considerations are not extended beyond the caloric content of the diet since, it is assumed, protein needs will be satisfied by the strong utility of meat and milk products in the objective function, and other nutrient needs can be satisfied by supplementation. Presumably the model is not ultimately restricted to this limited nutrient domain.

2.4.1.2 Menu Planning Models

Menu or meal planning is a decision process of defining the serving sequence and/or serving frequency of prepared foods, called menu items, such that required nutritive, production, economic, and palatability constraints are satisfied (Balintfy 1973b; Balintfy 1976a). Two approaches to menu planning by computer have been reported -- a non-mathematical method called the "random approach" (Eckstein 1967) and a mathematical modelling approach which has evolved to include a variety of linear and nonlinear programming models (Balintfy 1976a).

2.4.1.2.1 Menu Planning Models - The Random Approach

The random approach to menu planning (Eckstein 1967) attempts to simulate the routine decision making processes used by dieticians in planning menus. The menu is compiled by randomly selecting items from a variety of meal component classes and sequentially evaluating these items against predetermined acceptability criterion used by dieticians. These criteria include colour, texture, shape, flavour, caloric content and cost of the food item, as well as other acceptability factors. Items from each meal component that satisfy the criteria are included in the solution.

The random approach is based on the concept of bounded rationality -- a decision process where acceptable solutions are reached without considering all the possible alternatives. This approach to menu planning has been largely supplanted by mathematical programming methods which, by contrast, produce optimal solutions based on considering all the possible alternatives (Balintfy and Nebel 1966).

2.4.1.2.2 Mathematically-Programmed, Multistage, Menu Planning

Menu planning as a mathematical programming problem was first identified and solved by Balintfy (1963; 1964). This first approach used a multistage decision rule which planned an optimal combination of menu items for a sequence of meals by considering the problem of scheduling on a sequential meal-by-meal, day-by-day basis. This model has been formulated in both a linear programming version (Balintfy 1966; Neter and Wasserman 1970) and as an integer programming version which approximates the theoretical solution to the problem (Balintfy 1964; Gue and Liggett 1966).

This first model utilized menu-item quantities of fixed-portion size as decision variables to produce a nonselective menu. Such a nonselective menu is obtained by assigning one menu item to each of several menu-item classes or courses (for example, appetizer, entree, cereal, bread, and beverage for breakfast courses) over a defined period of time. Gue and Liggett (1966) have extended the concept of menu-items as decision variables to fixed-choice groups of two or more items, and thereby developed selective menu planning model. Selective menu planning allows a choice of items from each menu item class. This concept has been further extended to selective menu planning from variable-choice groups by Balintfy (1971).

A refined model based on the above approach was converted into a self-contained food services information processing and menu planning computer package, called "System/360 Computer Assisted Menu P nning" or "CAMP" (Balintfy 1969), for use in institutional food planning in the public domain. The system includes a systemmatic approach to data collection and data management, as well as to menu planning (Balintfy 1975).

The menu-planning objectives, which define optimality in the CAMP system, are to determine the least-cost combination of menu items for a sequence of days which meet nutritional and acceptability requirements Balintfy (1975). Item acceptability and dietary variety are provided by structural, separation, and attribute constraints which ensure compatitility of items between meals and within meals. Compatibility within meals is provided by use of attribute codes which restrict the entry of items of similar attributes from appearing more than desired in any meal. Further, formal requirements on the structure of the menu are imposed. The structural requirements partition the menu into a customary array of menu components for each meal, to which only appropriate menu items can be assigned. Compatibility between meals is achieved by separation constraints which indicate the desired serving frequency. The separation constraint defines a minimally elapsed number of days between consecutive rescheduling of the same or similar items. Other constraints on proportionality of items, and on production requirements are also included. The constraints used in CAMP are based upon the expressed preferences of patients and upon institutional policy.

CAMP has provisions for selective and nonselective menu planning (Balintfy 1975). Selective menu planning is intended to further enhance menu acceptability. Although structural, attribute, and separation constraints are operative in selective menu planning, nutritional constraints are not. It is reasoned that is nutrient-assured meals are required the nonselective first choice must be accepted.

Multistage menu planning has evolved to include procedures for variable portion-size and chance-constrained modelling. Armstrong and Sinha (1974) have developed a quasi-integer programming algorithm to plan nonselective menus in which the portion size of the menu items can vary over a specified positive range. This is an advance over earlier systems in which fixed portion size was a technical necessity. Another advance is demonstrated by Balintfy (1976a) with the introduction of random variables as constraints. This particular application considers the nutrient content of any item in probabilistic terms and the constrained solution as meeting nutrient requirements individually or collectively with a specified probability.

Multistage menu planning can also incorporate recently developed nonlinear preference maximization objectives which utilize some measure of consumer satsifaction (Balintfy 1976a). Typically cost-minimization objectives have been used since adequate quantitative measures for consumer preference were absent, and since earlier modelling objectives were chosen to demonstrate the economic impact of mathematical optimization as opposed to conventional methods (Balintfy 1973b). The use of preference maximization objectives has been demonstrated in single-stage menu-planning models to be discussed.

Multistage menu planning has been implemented in a variety of institutional food services including hospitals, colleges, penal and mental institutions. Applications of the CAMP system (Bowman and Brennan 1969; McNabb 1971; Gelpi et al. 1972; Balintfy 1975) have demonstrated savings of 5 to 34 percent in raw food costs, improvements in nutritive control, and equivalent acceptability and variety standards as compared to conventional techniques. Prototypes of the CAMP system (Balintfy 1964; Balintfy and Nebel 1966) and other multistage systems (Gue and Liggett 1966) demonstrate similar advantages.

2.4.1.2.3 Mathematically-Programmed, Single-Stage, Menu Planning

Menu planning can be done in a single stage when the frequency of occurrence of menu items over a finite time period is to be determined and not the specific sequence of items in the menu is to be determined (Balintfy 1973b; Balintfy 1976a). Unlike multistage menu planning which provides a consecutive sequency of integer solutions for each of the smallest periods within the planning horizon, single-stage menu planning offers only one mathematical solution for the entire cycle (Balintfy 1966). The common shortcoming of single-stage solutions is that computer scheduling on a meal-by-meal basis is still required to provide a sequence of daily meals (Balintfy 1976a). The difficulty of scheduling for a fixed-time horizon in a single stage is discussed by Balintfy (1974a).

The first models incorporating single-stage menu planning (Balintfy 1966) inherited the cost-minimization objective and linear constraints on nutrients, structure, and attributes. The concept of minimum separation of items used in multistage scheduling, as a safeguard for variety, was used in single-stage models to establish upper bounds on the frequency of occurrence of items. Although the use of these upper-bound constraints was a crude method of maintaining preference levels, studies in a number of situations indicated single-stage menu planning models produced diets which met nutrition and acceptability levels while reducing costs (Gelpi et al. 1972; Balintfy 1976a).

With the discovery of time-related food-preference functions (Balintfy et al.1974) and time-related food-preference and quantity functions (Balintfy 1973b) it became possible to optimize the quantity and frequency of food intake based on an empirical measure of food preference or utility (Balintfy 1976a). Recent single-stage programming models have incorporated nonlinear objective functions which maximize measures of total food preference subject to given nutrient, cost, structural, and assorted attribute, proportionality, production, and other constraints -- constraints similar to those in CAMP (Balintfy 1974b; Balintfy 1976a)

An alternative non-linear programming formulation with the preference quantity functions has been proposed (Balintfy 1976a). This model maintains the linear cost-minimization objective normally used in institutional menu-planning models, and incorporates a nonlinear preference constraint which maintains a given food-preference level.

2.4.2 Information and Behavior Change

As indicated at the outset, the task of nutrition educators is both to provide a code of nutritional practice and to communicate this available knowledge to the public sector. One view is that this process is one of planned change, where planned change is "... a conscious effort to alter food-related practices or attitudes when the need exists" (Gifft et al. 1972, p. 255). Thus, the ultimate objective of nutrition education programs, according to this approach, is to modify food behaviour through deliberate intervention.

2.4.2.1 Development of Food Behavior and Factors in Food Selection

Food selection behavior, as with other human behaviors, is the product of a complex interaction of situational and developmental variables, and of individual and environmental variables. Situationally, food selection is dependent of two factors: food availability -- the environmental variable -- and food acceptability -- the individual-related variable (Gifft et al. 1972). The availability of food in the marketplace and home is of paramount importance in food selection behavior. Availability is governed by climatic and geographic factors, by economic, political and technologic factors, and by public policy and individual decisions (Gifft et al. 1972). A food's acceptability, in turn, determines which of the available items will be selected and eaten. Item acceptability for the individual is determined psychologically through motivations or needs, such as biogenic (sensory) needs, psychogenic (emotional) needs, and sociogenic (goal) needs; and through cognitions such as ideas, attitudes, and beliefs (Lund and Burke 1969).

Developmentally, the psychologic elements of an individual are rooted in the unique interaction of his or her biological nature and socio-cultural factors (Gifft et al. 1972). The intricate process of this social and emotional acculturation provides the food-related experiences which contribute to the development of food patterns, whereas the biological heritage determines the physiological needs and capacities, and the potential psychologic and sensory structures which will interact with the environment to create a person's food pattern.

Consequently, each individual has a characteristic pattern of eating which has developed over a lifetime as a result of many complex processes and influences, and which has an integral part of that individual's total behavior (Gifft et al. 1972). This pattern is resistent to change, especially complex change, unless immediate benefits are evident, or a change is forced by circumstance (Gifft et al. 1972). Much is vested in a particular pattern and the tendency is to move towards familiarity or to reinforce what is already known (Thompson 1969; Gifft et al. 1972). Future gains are obscured by the immediate rewards of not changing.

2.4.2.2 The KAP Gap[1]

Food practices do not change just because people have accurate facts about nutrition (Leverton 1974). Numerous studies in nutrition education (Hampton et al. 1967; Baker 1972; Bell and Lamb 1973)and other fields of applied education (Young 1967) have indicated the incongruity of different aspects of behavior. Material taught may not be learned, once learned it need not be believed, and even if a change in attitude did occur practices would not necessarily be altered. The reciprocal is also true. Behaviors are not based only on particular types of knowledge. In fact a person may not be able to justify his or her actions and beliefs to the satisfaction of others. For example, individuals may not be able to provide valid nutritional reasons for their nutrition practices (Emmons and Hayes 1973).

Although evidence of the effect of nutrition knowledge on food practice is limited and conflicting, some evidence does suggest that acquisition of formal nutrition knowledge is positively related to behavior change in

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1. For further discussion of the knowledge -- attitude-practice (KAP) gap see Travers (1963)

individuals (Young et al. 1956 a+b; Hinton et al. 1963; McKenzie and Mumford 1965; George 1971; Boysen and Ahrens 1972). Admittedly this is not a linear relationship (Gifft et al. 1972) indicate, studies comparing the influence of formal nutrition education on food practices are difficult to perform and interpret due, in part, to the conflict of other variables which may simultaneously effect behavior. These include factors such as emotional stability and maturation age (Hinton et al. 1963), informational sources besides the nutrition-intervention technique (Rosenstock et al. 1966), and early learning and food patterns (Litman et al. 1964; Brown 1967).

That nutrition education is able to influence the eating habits of populations, is illustrated most notably by the successful campaigns of various food companies (Tyler 1962; Gussow 1972; Manoff 1973) and other mass media campaigns (Rosenstock et al. 1966). In these cases, most campaigns were aimed at influencing product choice for reasons other than nutritional value. Therefore, there is some reason to believe, provided similar resources are available, that eating habits can be influenced for nutritional reasons (Manoff 1973).

In any case, accurate facts are essential for rational decisions, even though information on proper diet may not prevent, and may even result in contrary, incorrect, or exacerbating behavior. Information or messages are a source of guidance in food pattern development and redevelopment, and thus form a tool through which the nutrition educator can promote planned change (Gifft et al. 1972)

2.4.2.3 Increasing the Effectiveness of Communication

Although human behavior is complex and difficult to analyze, predict or manipulate, research has provided some principles and guidelines to increase the efficacy of the educational process, and thereby increase the chance of individual compliance with recommendations. However, precise predictions of the efficacy of using these principles are not possible (Gifft et al. 1972).

There are many approaches to and lists of principles for enhancing the effectiveness of educational programs (Gifft et al. 1972). The underlying theme of these principles is to enhance the learner's receptivity to the message by:

(i) increasing the learner's interest through:

(a) incentives such as teacher and program credibility, individualized involvement, and advertized benefits; and

(b) appropriate exposure to the message, for example, by enlisting the learner's active involvement in the learning situation, changing process demands, keeping messages short to ensure active attention, and emphasizing thinking versus recall activities (Gifft et al. 1972).

(ii) increasing the learner's receptivity by constructing a message of maximum potential meaning for the learner (Gifft et al. 1972).

In either case the focus is on the learner's relationship to the information rather than on the message alone. The present concern is with the construction of a message with maximum potential meaning for the learner, and not with the development of other aspects of the teaching-learning process used to increase the learner's receptivity.

Change occurs when the information provided is significant enough to the learner to motivate action (Gifft _et al_. 1972). It is axiomatic, in the field of communication theory (Berlo 1960), that response to bids for change are governed by the ratio between the anticipated benefit and the energy required to respond. The more reward, the more effort which will be put out, and the less reward the less the effort. Therefore, the potential response to a message can be increased by increasing the reward or decreasing the effort required, or both.

Expected benefits can be increased by choosing messages relevant to the learner's interests, perceived needs, and concerns (Gifft _et al_. 1972; Leverton 1974).

Effort to respond to recommended alterations in food practices can be decreased by gearing information to the physical and mental skills, cognitive sets, attitudes, resources, and emotional readiness of the receiver. For example, information can be adjusted to the individual's: physiological needs; psychological barriers such as values, attitudes, beliefs, likes and dislikes, and pursuits such as, family responsibilities, professional demands and leisure-time activities (Gifft _et al_. 1972).

An important consideration in decreasing the effort necessary to respond is complexity of change. Since people's food patterns remain relatively stable and are resistant to change, especially complex change, recommendations for change should avoid unnecessarily complex demands. Complexity of change has been suggested as perhaps " ... the strongest determinant of the speed and extent of adoption" (Gifft _et al_. 1972, p. 265). Thus, nutrition education programs are more effective when emphasis is placed on the maintenance of present desirable habits and the improvement of current food patterns rather than on radical alterations in diet (Todhunter 1969). For example, persuading a person to eat more of a food he or she already eats may be less complex and therefore easier to accomplish than inducing him or her to use a food which has neven been tasted (Gifft *et al*. 1972). Similarly, the individual should not be overloaded with information (Leverton 1974).

CHAPTER 3

DEVELOPMENT OF THE PROTOTYPICAL SYSTEM

3.1 Introduction

The project goal (p.13) was to develop a prototypical system to provide information on dietary practices for those adults who want to apply nutritional principles to their eating habits, and have sufficient resources (eg. time, energy, education, money) to make use of the information which defines healthful dietary practices for them. This development was undertaken bearing in mind two primary difficulties, coincident with nutrition education's aforementioned tasks (p. 1), namely: the problem of developing nutritional guidelines suitable for health promotion in the public sector, and the problem of communicating this information to individuals.

3.1.1 Developing Nutritional Guidelines

With respect to the issue of developing a message which incorporates accurate nutritional guidelines, standard dietary assessment procedure of data collection, analysis, and evaluation have been discussed (Section 2.3). These appear to be suitable for the prototypical system's design. Guidelines for evaluating diets can be derived from the dietary standards of various countries and international agencies, and the dietary goals proposed by recognized scientific agencies. This procedure has been considered despite certain problems, namely: considerable conflict exists about the formulation and application of dietary standards; dietary assessment alone does not provide the means to establish nutritional status; and "optimal" nutritional status cannot presently be defined.

3.1.2 Communicating Information to Individuals

With respect to the second problem, that of communicating this information to individuals with the ultimate objective of changing food practices, the use of educational principles was considered relevant to the system's development. The focus has been the development of a message for motivated individuals -- in this instance a statement about what to consume -- which facilitates adoption of recommendations. In this context, two features of the message are significant, namely: the comprehensibility of the information, and the acceptability of the suggested changes.

3.1.2.1 Comprehensibility of the Information

Education principles indicate that the comprehensibility of information recommending change in eating behavior can be increased by not overloading the client with unnecessary information. In particular, recommendations for change in eating habits should not require extensive alteration in the person's perception of his food environment and eating habits. The type of information typically presented in nutrition education programs is either an explicit statement about foods to consume, for example as a daily menu, or alternatively an implicit statement, for example as a daily nutrient allowance. Although the presentation of nutrient information may provide a clear rationale for food selection, nutrient information becomes functional only when translated into foods and meals. Thus, a statement based on foods to consume should be easier to comprehend than one based on nutrients.

In developing such a food-based statement, the emerging problem is to accurately translate nutrient requirement data into a viable food plan. The problem arises because the nutrient contribution of each food with its characteristic nutrient pattern must be considered in developing the diet plan. As the number of nutrients under consideration increases and the restrictions on acceptable solutions become more severe, the accounting problem becomes formidable. Mathematical-programming techniques, based on experimental menu-planning procedures for food service applications and on a variety of programs with industrial applications, are useful in overcoming these problems. They provide for simultaneous satisfaction of many variables, including nutritive, production, economic, and palatability constraints. This method may be used for nutrition education purposes to resolve the problem of accurately translating data on nutrient requirements and food composition into a viable food plan.

3.1.2.2 Acceptability of Suggested Changes

The acceptability of suggested changes can be increased by limiting the complexity of change. Complexity of change has been suggested as perhaps the strongest determinant of the speed and extent of adoption. Thus, nutrition education programs are more effective when emphasis is placed on the maintenance of presently desirable habits and the improvement of current food patterns rather than on radical alterations in diet. Factors which may contribute to the perceived complexity of these changes include: budgetary considerations, socio-cultural patterns, foods available, food habits, taste preference, colour preferences, likes and dislikes, needs and interests, and beliefs about foods. In short, any deviation from the characteristics of a usual or desired food pattern may contribute to the perceived complexity of change.

Hence the best approach for compliance with nutritional recommendations should be a diet which deviates as little as possible from a dietary inventory identified as desirable either by past consumption[2] or stated preference. Presumably, this would be similar to the diet which the individual would choose if she or he understood, accepted, and used nutrition knowledge. Using the mathematical-programming techniques previously mentioned, a constrained-optimization algorithm can be formulated to find the combination of foods which are similar to an individual's actual or desired food plan while simultaneously considering nutritional, budgetary, and palatability requirements, or for that matter, any other measurable vector of food or food-selection behavior.

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2. Usual food pattern may provide a better monitor of actual preference, being the diet chosen under present budgetary restrictions and long term cultural and personal habits.

3.2 System Design and Characteristics

The prototypical system, as illustrated below in Figure 3.1, is designed both to assess and plan diets by systematizing the procedures used in dietary analysis and counselling by nutritionists and dietitians. Input data from both a client questionnaire and computer files are processed within the two phases of analysis-evaluation and planning. Within this framework, the nutrient characteristics of the client's initial diet can be analyzed and evaluated, and a diet plan can be produced which should remain close to an individual's actual or desired food plan while simultaneously meeting specified nutrient limits. The outcome of this procedure is an output statement of: the client's initial diet; a recommendation of altered food intakes -- the revised diet; and an analytic and evaluative statement of the original nutrient intake.

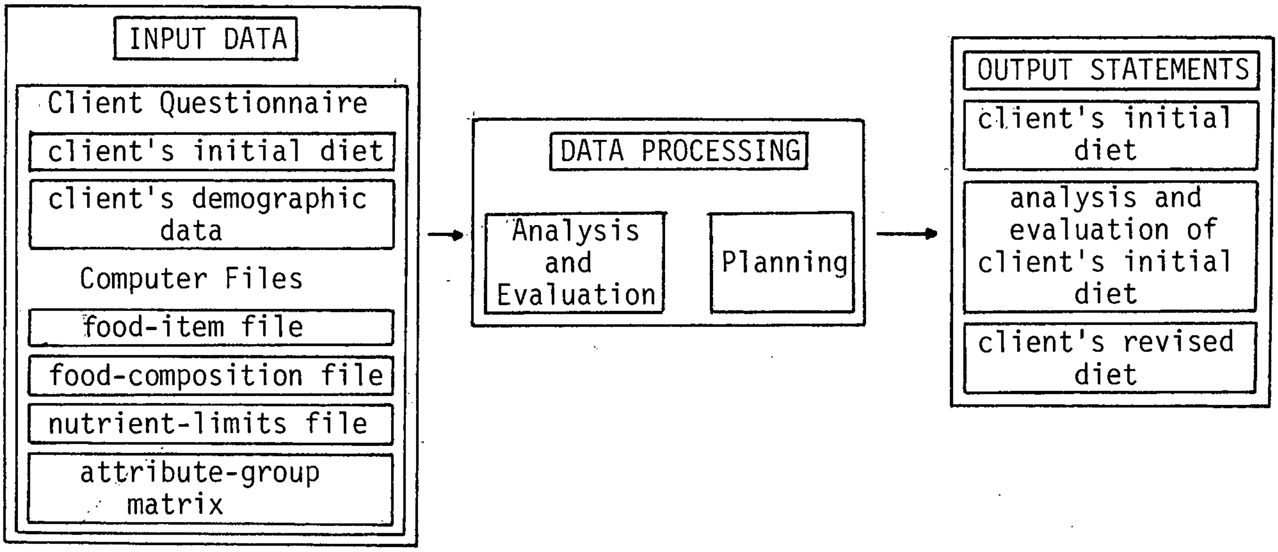

Figure 3.1 Overview flowchart of prototypical system for assessment and planning of individual's diets.

3.2.1 Data-Collection

3.2.1.1 Client's Initial Diet

The client's initial diet includes those food items and their quantities, selected from the system food-item file (Appendix A), which the client consumes habitually.[3] This information is used both in diet-assessment and in diet-planning, since it provides the basic data with which food-composition analysis and evaluation can be performed in diet-assessment and with which the client's diet and dietary-structure can be defined in the planning phase. The client's initial diet is stored in the system during processing and compared with the revised diet on the output presentation.

The client's initial diet is determined by using a multiple-purpose intake questionnaire (Table 3.1) which permits use as a one-day recall, weekly record, long-term food frequency history, or other variants. Items can be quantified by weighing, by household measures using standard portion-sizes or measured portions, or by estimation. The questionnaire can be self-administered by the client, or used in an interview format for supervised inquiry. The individual and/or institution can select the most appropriate data-collection procedure for their purposes. Flexible data collection procedures may be more useful for meeting the variety of client requirements, program capabilities, and other situational factors.

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3. Alternatively, the diet can represent the desired regime or a diet previously designed in collaboration with a nutritionist.

Table 3.1 Excerpt from prototypical intake questionnaire -- dietary intake format.*

FOOD ITEMS AND DESCRIPTION	AMOUNT PER UNIT SERVING		CONSUMPTION FREQUENCY		
	STANDARD PORTION SIZE	ADJUSTED PORTION SIZE	SERVINGS PER		
			DAY	WEEK	MONTH
ENTREE ITEMS -- DAIRY AND EGGS					
AMERICAN PROCESSED CHEESE.	1"-1"-1½" (1 oz.)				
BLUE or ROQUEFORT CHEESE.	1"-1"-1½" (1 oz.)				
CHEDDAR, JACK or SWISS CHEESE	1"-1"-1½" (1 oz.)				
COTTAGE CHEESE, creamed or uncreamed, any curd.	½ cup (4 oz.)				
CREAM CHEESE or CHEESE SPREADS.	2 tbsp. (1 oz.)				
SOUR CREAM or CHIP DIP.	1 tbsp.				
YOGHURT, whole milk base.	1 cup				
YOGHURT, skim milk base.	1 cup				
YOGHURT, part-skim milk base.	1 cup				
EGG: raw, boiled, poached, fried (add fat).	1 egg				
EGG: scrambled, omlet, souffle, spoon bread.	2 eggs				
ENTREE ITEMS -- CEREALS					
CORN CEREAL, enriched, ready-to-eat.	1 cup (1 oz.)				
WHEAT CEREAL, enriched, ready-to-eat.	1 cup (1 oz.)				
WHEAT CEREALS, more refined, enriched: cooked.	½ cup				
OATMEAL, all types: cooked.	½ cup				
WHEAT CEREALS, less refined: cooked.	½ cup				
PANCAKES, WAFFLES or FRITTERS: made with milk and eggs	2 at 4" dia.				
NOODLES, egg-type, enriched: cooked.	½ cup				
SPAGHETTI, MACARONI or NON-EGG PASTAS, enriched: cooked	½ cup				
RICE, brown: cooked.	½ cup				
RICE, white, enriched, unenriched or parboiled: cooked	½ cup				
CORNMEAL or CORN GRITS, enriched: cooked.	½ cup				
WHEAT GERM.	3 tbsp. (1 oz.)				
FRENCH or SOURDOUGH BREAD, enriched: fresh or toasted.	1 slice				
RAISIN or RAISIN-NUT BREAD, enriched: fresh or toasted.	1 slice				
ETC.................... ETC..................					

* A complete list of foods and portion sizes is contained in Appendix A.

The questionnaire food items, contained in the system food-item file (Appendix A), were derived from the "Mini Food List with Food Substitutions" developed by Pennington (1976). Pennington's Mini Food List contains a table of 202 commonly-consumed American food-items, called index items, and a comprehensive list of 49 compositional values for each of these index items. Each index item represents one-or-more substitutable items classified according to the coexistence of the 49 nutrient values.

In order to develop the system's food-item file, 200 of Pennington's 202 index items were selected. This initial list was elaborated to incorporate most of the substitution items within their pre-assigned groups in order to fit the system's attribute-group matrix. The food item file (Appendix A) developed contains 221 item clusters, where an item cluster is composed of either a single item or two or more exchangable items of similar nutrient characteristics. An abridged food-item file (Appendix B) of 127 item clusters was developed for testing the system.

The item clusters have been categorized within a hierarchical structure of groups and subgroups used for planning purposes, called the attribute-group matrix (Appendix G). Each of the item clusters was assigned an attribute-group code number and an item cluster code number which appears with the item in Appendix A and B. The makeup of this hierarchy is discussed further in the material on diet-planning (p. 121).

To aid in quantification of questionnaire items, the description of portion sizes in the system food-item file has been elaborated beyond that available from Pennington's text. Food Portions Commonly Used (Church and Church 1975) and Agriculture Handbook No. 456 (Adams 1975) were used in this extension. This procedure was not in every case free of difficulty as noted in Appendix A, since the descriptions of standard portions per gram quantity, used by the three authors, were considerably different in some instances.

Manual computer input of the questionnaire data was used. Alternative input methods such as interactive terminal interviewing or computer read cards, although perhaps preferable in on-going use required for present purposes.

3.2.1.2 Client's Demographic Data for Defining Nutrient Limits

Data on the individual's sex, age, size, activity pattern, and pregnancy status are collected on the questionnaire (Table 3.2). This information is used in the assessment and planning phases of the program to define the nutrient limits appropriate to the individual.

Table 3.2 Excerpt from prototypical intake questionnaire -- client demographic data.*

AGE (in years) ____ IDEAL BODY WEIGHT (in pounds) ____

SEX and PREGNANCY STATUS (check one)

male __ female not pregnant __ female pregnant 1st trimester __ female pregnant 2nd or 3rd trimester __ female lactating __

ACTIVITY PATTERN (select pattern appropriate for sex from table below and check one) A __ B __ C __ D __

Types of Activity	Act. Pat. (men)				Act. Pat. (women)			
	A	B	C	D	A	B	C	D
	No. hours/day				No. hours/day			
1) Resting metabolism	8	8	8	9	8	8	8	9
2) Sitting or standing still	10	10	12	13	11	11	12	13
3) Walking slowly Light domestic work (eg. ironing, sweeping floor, cooking, dishwashing, dusting) Light office of industrial work (eg. typing, lab. work, sewing, printing, garage mechanics, machine-tool operation) Sports involving light activity (eg. bowling, golf, sailing)	4	5	4	2	4	5	4	2
4) Walking at moderate speed Moderate domestic work (eg. scrubbing floor, window cleaning, furniture polishing) Moderate industrial work (eg. painting, plastering, brick-laying, modern farming) Hobbies with moderate activity (eg. gardening, woodwork, dancing) Active sports (eg. tennis, cycling, skiing, gymnastics, swimming)	2	1	0	0	1	0	0	0
Total	24	24	24	24	24	24	24	24

* Adapted from the Dietary Standards for Canada (Canada 1975).

3.2.2 Data-Analysis

Following collection of dietary data, the client's initial diet is analyzed for nutrient values. Nutrient data used for this analysis and for generating the new diet plan are contained in the system's food-composition file (Appendix C).

The food-composition file is stored in the system for retrieval during operation. It is derived from Pennington's Mini Food List (Pennington 1976), and includes 41 composition values in nutrients per 100 grams of edible food portions for each item cluster in the food-item file. The nutrient values contained are for total calories; protein and eleven amino acids (tryptophan, threonine, isoleucine, leucine, lysine, methionine, cystine, phenylalanine, tyrosine, valine, histidine); total, saturated, and polyunsaturated fatty acids; cholesterol; total carbohydrate; sucrose; fiber; twelve vitamins (thiamin, riboflavin, niacin, pyridoxine, folate, cobalamin, ascorbate, pantothenate, biotin, retinol, cholecalciferol, tocopherol); and nine minerals (calcium, phosphorus, magnesium, iron, iodine, zinc, sodium, potassium, copper). It was assumed that the values obtained from Pennington's publication are applicable to the Canadian marketplace.

The composition values used are specific for processing and preparation effects outlines with the item description. Consequently, recipes using raw items cannot necessarily be calculated from baked items due to changes in weight with cooking. Further Pennington (1976) suggests that:

> when possible, fresh cooked items should be substituted by fresh cooked; canned by canned; and frozen cooked by frozen cooked. This will prevent large errors in water-soluble vitamins, sodium, and vitamin-E (p. 16).

The sodium content of items is without either salt added at the table or salt added in preparation. Therefore, any added salt must be included as salt listed in the food-item file.

An abridged food-composition file (Appendix D) of 22 nutrients was developed to coordinate with the abridged food-item list of 127 item clusters contained in Appendix B, and to provide a reduced composition format for system testing. The nutrients selected for the file are as follows: total calories; protein; total, saturated, and polyunsaturated fatty acids; total carbohydrate; sucrose; fiber; nine vitamins (thiamin, riboflavin, niacin, pyridoxine, folate, ascorbate, retinol, cholecalciferol, tocopherol); and five minerals (calcium, phosphorus, magnesium, iron, potassium).

For the nutrient tally, the aggregate available quantity of any nutrient is assumed to be the sum of the quantities contained in each of the foods consumed. No allowance has been made for factors that reduce the availability of nutrients, either in a particular item or in other foods eaten simultaneously, with the exception of cashews, spinach, and spinach substitutes where oxalate concentration has been considered. Therefore, the total nutrient composition of the diet is the summation across all foods for each nutrient, namely:

$$(3.1) \qquad \sum_{i=1}^{n} a_{qi}\, x_i^o \qquad\qquad (q = 1, 2, \ldots, m)$$

where:

x_i^o is the amount of item cluster i per period time in the original diet. An item cluster is a single item, or two or more substitutable items of a similar nutrient composition.

n is the total number of item clusters in the diet. n is 221 (Appendix A) or 127 (Appendix B).

a_{qi} is the amount of nutrient q in a unit of item cluster i. The values for a_{qi} are contained in the m x n matrices of food composition (Appendix C or D).

m is the total number of nutrients considered in dietary analysis -- either 41 (Appendix C) or 22 (Appendix D).

3.2.3 Data-Evaluation

In the data-evaluation phase the system evaluates the client's initial diet by comparing calculated nutrient-intake with nutrient limits which are individualized for the client. The evaluation output comprises a graphical and/or tabular display of the quality of the diet. The output format utilized is shown in Table 3.3. This provides a functional tabular output for system testing and development. An example of a proposed output format (Table 3.4), which is modelled on the "Nutrient Quality Index" (Wittwer et al. 1977), incorporates a graphical presentation of the evaluation output.

Table 3.3 Excerpt from the evaluation output format used for system testing

NUTRIENT	MINIMUM (/week)	MAXIMUM (/week)	INITIAL DIET (/week)	REVISED DIET (/week)
PROT (gm)	392.00	558.60	818.46	558.60
CHO-T (gm)	2735.4	4476.1	1572.2	2735.4
T-FAT (gm)	44.209	663.13	825.87	566.47
KCAL	18899.	20889.	18366.	19301.
CHO-F (gm)	79.576	159.15	21.596	79.576
SFA (gm)	.0	221.04	363.74	208.08
SUCR (gm)	.0	746.02	396.53	746.02
PUFA (gm)	44.209	663.13	445.79	317.61
VIT-A (iu)	35000.	.14000E+06	44903.	72916.
VIT-D (iu)	700.00	4200.0	1623.6	1244.7
VIT-E (mg)	63.000	700.00	48.232	63.000
etc.......	......	....	....	......

Table 3.4 Excerpt from a proposed evaluation output format.*

The table below contains an estimate of your average daily nutrient intake over a period of (1 day, 1 week, 1 month or longer), and a comparison of your estimated intake with minimum and maximum intake standards for an individual with the following characteristics: (activity, sex, age, size, pregnancy status). The table also indicates the average daily amount of nutrients provided by a diet recommended for you, if your old diet does not meet the standards.

Nutrient	Recommended Intake /day Min.	Recommended Intake /day Max.	Estimated Diet Intake /day Old	Estimated Diet Intake /day New
Energy (kcal)	2700	2984	2624	2757
Protein (gm)	56	80	117	80
Carbohydrate (gm)	391	639	225	391
Fiber (gm)	11	23	3	11
Fat (gm)	6	95	118	80
etc..........	....	....	....	....

Nutrient	Estimated old dietary intake as % of minimum recommended intake	Estimated new dietary intake as % of minimum recommended intake
Energy (kcal)	xxxxxxxxxxxxxxxxxx 100%	xxxxxxxxxxxxxxxxxxxxx 100%
Protein (gm)	xxxxxxxxxxxxxxxxxxxxx	xxxxxxxxxxxxxxxxxxxxxxxxxxxx
Carbohydrate (gm)	xxxxxxxxxxxxxxx	xxxxxxxxxxxxxxxxxxxxxx
Fiber (gm)	xxxxxxxxxx	xxxxxxxxxxxxxxxxxxxxxx
Fat (gm)	xxxxxxxxxxxxxxxxxxxxx	xxxxxxxxxxxxxxxxxxxxxxxxxxxx
etc........	....	....

Nutrient	Estimated old dietary intake as % of maximum recommended intake	Estimated new dietary intake as % of maximum recommended intake
Energy (kcal)	xxxxxxxxxxxxxxxxxx 100%	xxxxxxxxxxxxxxxxxx 100%
Protein (gm)	xxxxxxxxxxxxxxxxxxxxx	xxxxxxx
Carbohydrate (gm)	xxxxxxxx	xxxx
Fiber (gm)	xxxx	xxxxxx
Fat (gm)	xxxxxxxxxxxxxxxxxxxxx	xxxxxxxxxxxx
etc.........	....	....

The following nutrients, although essential for the maintenance of health, have not been included in assessing your diet: (water, chromium, etc....). The following factors are not considered to be nutrients and consequently are not included in assessing your diet: (nucleic acid, popsicle magic factor, etc....).

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* Nutrient values presented in the evaluation output could correspond to the total evaluation file, to selected values as requested by the client or as needed by the counsellor for illustrating diet problems, or to composites of groups of nutrients

The nutrient-limits file (Appendix E) provides the basic data, used in both the assessment and planning phases of the program, to define the range of appropriate nutrient intake for a given period of time. This file is stored in the system for retrieval during operation.

Nutrient limits for the client are generated from the values contained in the nutrient-limits file by applying the rules outlined in Appendix E. These rules are used to translate values from the nutrient-limits file to measurement units which are common to those of the food-composition file, and to individualize these for the client based on the client's demographic data collected on the questionnaire (p. 113). Nutrient limits expressed as ratios of two nutrients do not require this modification.

The nutrient-limits file contains maximum and minimum nutrient limits expressed as nutrient ratios, as quantities per day, and as quantities per kilogram per day. These limits are disaggregated by age, sex, activity level and pregnancy status. Standards from Health and Welfare Canada, and recommendations from other established nutrition sources, have been used to designate minimum nutrient limits. As indicated, these values with their respective sources have been outlined in Appendix E. It should be noted that the philosophy of the "Dietary Standard" has not been represented in the development of every lower intake limit used in the system. This is due, in part, to the inclusion of "nonessential" nutrients in the evaluation phase -- for example sucrose, saturated fatty acids, and fiber. For these components a lower limit of zero was used, unless benefits from some intake were documented. Where dietary standards were not available for essential nutrients included in the system, such as polyunsaturated fatty acids, sodium, and potassium, a measure of minimum maintenance was used as outlined in Appendix E. Other suggested indices of dietary well-being not specifically included in the Dietary Standard, such as poly-unsaturate and saturate ratios, calcium/phosphorus were also included in the nutrient-limits file. Similarly, maximum limits have been empirically based where possible, and otherwise are arbitrarily set at twice the minimum value for present test purposes. Maximum and minimum energy intakes have been arbitrarily set at plus or minus five percent of the intake for any age, sex, and activity category.

In total, 82 nutrient limits -- 41 maximum and 41 minimum -- have been assigned. These values correspond to the 41 food compositional values in Appendix C with a few exceptions. First, in addition to specific limits on calcium, phosphorus, polyunsaturated and saturated fatty acid intake, restrictions have been included on the ratios of polyunsaturated to saturated fatty acids and of calcium to phosphorus. Second, instead of maximum and minimum limits for each of the eleven amino acids, only 18 limits have been imposed to cover 7 single amino acids and 2 pairs of amino acids -- phenylalanine and tyrosine; methionine and cystine.

An abridged nutrient-limits file (Appendix F) has been designed for system testing. This table has 24 minimum and 24 maximum standards to coordinate with the abridged food-composition file (Appendix D) and food-item list (Appendix B). The nutrients considered are: total calories; protein; total, saturated, and polyunsaturated fatty acids; polyunsaturate to saturate ratio; total carbohydrate; sucrose, fiber; nine vitamins (thiamin, riboflavin, niacin, pryidoxine, folate, ascorbate, retinol, cholcalciferol, tocopherol); five minerals (calcium, phosphorus, magnesium, iron, potassium); and calcium to phosphorus ratio.

3.2.4 Diet-Planning

The system described thus far, has analyzed the nutrient composition of the client's diet and evaluated the client's diet by comparing the diet to nutrient limits. If the client's initial diet does not meet these limits, then the system generates a revised diet for the client. This computer prints out this revised diet for comparison with the initial diet. Table 3.5 illustrates the numerical listing of the item clusters with quantities in grams per week for the initial and revised diets.

Table3.5 Excerpt from the diet-planning output format used for system testing.

Item Cluster Code Number	Initial Diet (100 gram/week)	Revised Diet (100 grams/week)
003	2.2400	3.9887
004	0.0	0.0
005	0.0	0.0
006	0.0	0.0
008	1.1000	0.0
010	0.0	3.5409
012	0.0	1.5189
013	7.2000	4.4315
015	3.6000	0.0
016	0.0	0.0
017	0.0	0.0
018	0.0	0.4904
019	3.0000	3.0426
020	0.0	0.0
021	0.0	0.0
023	0.6900	0.0
024	1.3800	3.0740
027	0.0	0.0
028	1.3800	0.6316
031	0.0	0.0
...	......	......

The revised diet is developed by a constrained-optimization formulated to find the combination of item clusters that minimizes the sum of the squared differences between the amount of specific item clusters and of attribute groups[6] in the initial and revised diet, while satisfying nutrient constraints. The formal mathematical statement of the model is:

$$\text{(3.2)} \quad \text{minimize} \quad \sum_{i=1}^{I} w_i (x_i - x_i^o)^2 + \sum_{k=1}^{K} \sum_{j=1}^{j_k} P_{jk} \Big(\sum_{i \in G_{jk}} (x_i - x_i^o) \Big)^2$$

$$\text{(3.3)} \quad \text{subject to} \quad m_q \geqslant \sum_{i=1}^{I} a_{qi} \, x_i \geqslant n_q \qquad (q = 1, 2, \ldots, Q)$$

$$\text{(3.4)} \quad r_{uv} \geqslant \frac{\sum_{i=1}^{I} a_{ui} \, x_i}{\sum_{i=1}^{I} a_{vi} \, x_i} \geqslant t_{uv} \qquad (u,v = \text{any specified set of nutrient pairs})$$

$$\text{(3.5)} \quad x_i \geqslant 0 \qquad (i = 1, 2, \ldots, I)$$

where: x_i is the amount, in grams, of item cluster i per time period in the revised diet. The values of x_i are assumed to be additive and independent.

x_i^o is the amount, in grams, of item cluster i per time period, in the client's initial, desired, or nutritionist-prescribed diet, as determined from the client questionnaire.

I is the total number of item clusters in the diet. The I vector equals 221 in the complete food-item file (Appendix A), or 127 when the abridged food-item file (Appendix B) is considered.

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5. As indicated, an item cluster is one item, or two or more food items, varieties of an item, or prepared variations of an item which are considered nutritionally equivalent.

6. An attribute group is a group of item clusters with similar characteristics or attributes (see Appendix G).

K is the total number of hierarchical levels in the model, namely seven. Each hierarchical level corresponds roughly to a criterion for classifying item clusters into attribute groups on the basis of item similarities. The designated attribute groups form a hierarchical pyramid of groups and subgroups. The matrix of the hierarchical levels and attribute-groups is given in Appendix G.

The matrix developed is based, in part, on the examples of food classification schemes by other authors (FAO/WHO 1949; Davenport 1964; Gue and Liggett 1966; Chandler and Perloff 1975; Canada 1977). It represents an attempt to direct appropriate food substitutions among items of the food list by, first, defining general food and diet attributes that may important for indicating an item's or a diet's similarity to another item or diet. Second, foods are classified into groups according to these attributes. By attempting to provide the nearest acceptable substitute for any change in the quantity of an item or class, the compatibility relationships among items and the general characteristics of the altered diet should be most successfully maintained. For further discussion refer to Section 4.2 (p.136).

J is the total number of attribute groups j in the diet. J equals 278 in the large model and 178 in the abridged model.

J_k is the number of attribute groups j in the k^{th} hierarchical level. In the large model J_1 = 67, J_2 = 55, J_3 = 52, J_4 = 38, J_5 = 35, J_6 = 27, and J_7 = 4. In the abridged model matrix J_1 = 50, J_2 = 39, J_3 = 34, J_4 = 23, J_5 = 20, J_6 =12, and J_7 = 4.

G_{jk} is the set of item clusters i within the j^{th} attribute group of the k^{th} level. The total amount of food within any attribute group is the sum of the quantities of item clusters contained in that group. The item quantities are assumed to be additive and independent; that is, it is assumed that the common characteristic of items within any group can be measured by the aggregated quantity of the contained item clusters, and that an item cluster can hold simultaneous membership in any number of groups.

w_i is the weighted penalty associated with deviations of item cluster i from the desired amount. Values of w_i have been assumed in the absence of empirical data. These values are discussed in Chapter 4 (p.145).

P_{jk} is the weighted penalty associated with deviations of the j^{th} attribute group in the k^{th} level from the desired amount. Values of P_{jk} have been assumed in the absence of empirical data. These values are discussed in Chapter 4 (p.182).

a_{qi} is the amount of nutrient q in a unit portion of item cluster i. The values of a_{qi} are obtained from the I x Q matrix of food composition (Appendix C or D) which contain nutrient coefficients for edible 100 gram portions of foods. The aggregate available quantity of any nutrient is assumed to be the sum of the quantities contained in each of the foods consumed. The elements of the food composition table are assumed to be additive and independent, and to be constants. Allowance has not been made for factors that reduce the availability of nutrients in either a particular item or in other foods eaten simultaneously, with the exception of cashews, spinach, and spinach substitutes where the effect of oxalate concentration has been considered.

Q is the total number of nutrients q considered in the diet. For the large model, Q is 41; for the abridged model, Q is 22. The nutritional adequacy of solutions for mathematical diet-models can only be assumed for those nutrients specifically included in the model. For this reason, the large-model formulation incorporated as many nutrient values as was reasonably possible.

m_q and n_q are Q vectors of respectively, the maximum and minimum amount of nutrient q allowed in the individual's diet over a defined time period according to the client's age, sex, size, activity and pregnancy status. Values for m_q and n_q are derived from the nutrient-limits file (Appendix E or F).

a_{ui} and a_{vi} are the amounts, respectively, of specified nutrients u and v in a unit of item cluster i. u corresponds to either calcium or polyunsaturated fatty acids. v corresponds to either phosphorus or saturated fatty acids. Values of a_{ui} and a_{vi} are contained in Appendix C and D.

r_{uv} and t_{uv} are, respectively, the maximum and minimum allowed ratio for the nutrient pair (u,v). The nutrient pairs considered are calcium and phosphorus, and saturated and polyunsaturated fatty acids. Values of r_{uv} and t_{uv} are derived from Appendix C or D.

The objective function (Eqn. 3.2) defines a list of item clusters by minimizing the aggregate squared difference between specified characteristics of the initial and revised diets. The first term of the objective function sums the weighted squares of the difference between the amounts of item clusters in the initial and revised diets. The second term sums the weighted squares of the difference between the initial and revised amounts of a hierarchical sequence of item cluster groups, called attribute groups. The quadratic term introduces disproportionately larger penalties as the revised diet deviates more widely from the initial diet. This characteristic of the objective function tends to spread deviations uniformly over all item clusters and all attribute groups.

The modelling constraints comprise: nutrient constraints (Eqns. 3.3, 3.4) which designate maximum and minimum limits for the nutrients provided by the diet, and a non-negativity constraint (Eqn. 3.5) which prevents entry of non-negative quantities of variables in the solution. With respect to the nutrient constraints, only those which can be stated either as a fixed amount (Eqn. 3.3), or as linear ratios of two nutrients (Eqn. 3.4) are incorporated in the model. As written the second constraint (Eqn. 3.4) is a nonlinear equation. However, it is easily transformed into linear form. Apart from Equation 3.4, nonlinear constraints were not considered in the model.

The model was formulated into matrices suitable for input into a preprogrammed quadratic package based on Lemke's Complementary Slackness Algorithm (Cottle and Dantzig 1968; Lemke 1968). The matrix algebra formulation can be briefly outlines as follows:

Minimize: $c' x + \frac{1}{2} x' D x$

Subject to: $A x \geq b$

Where: $x \geq o$ is the vector of foods.

c' is a vector containing the coefficients for linear terms in the objective function.

D is a matrix containing the coefficients of quadratic terms in the objective function.

A is the food composition matrix.

b is the vector of nutrient constraints.

CHAPTER 4

TESTING OF THE PROTOTYPICAL SYSTEM

4.1 Introduction

The second project objective (p.14) involved testing of the diet-planning phase of the system, since this phase was considered to be the most significant obstacle to overall system development. This testing was restricted to a descriptive evaluation of some of the objective function's characteristics. Specifically, assumptions defining the concept of minimum deviation between diets, which are implicit in the objective function, were articulated and then explored by altering some of these assumptions and observing the consequences for revised diets developed for hypothetical individuals. The impact of altering nutrient constraints was not considered.

This evaluation was undertaken to explore the conceptual and technical feasibility of using a mathematical model to provide an effective dietary recommendation -- the individual's nutrient-constrained food-choide -- from a dietary inventory identified as desirable for the individual by his or her past consumption or stated preference. Also, it provides a basis for more definitive evaluation and development of the model. Explorative evaluation does not constitute the means to validate[7] the diet-planning model's design.

In order to reduce computational costs and clerical work required for evaluation of the diet-planning phase, all testing was done using the abridged data bases outlined in; Appendices B (abridged food-item file),

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7. Validation tests that the model is a reasonable representation of reality.

D, (abridged food-composition file), F (abridged nutrient-limits file), and G (attribute-group matrix). The nutrient constraints for test runs were determined from Appendix F for a standard male subject of age 19 to 35, activity level code B, and 70 kilograms body weight. The nutrient assigned for this standard subject for a weekly period are outlined below in Table 4.1. The daily intake equivalent is also provided for comparison.

Table 4.1 Upper and lower nutrient constraints* for a standard subject+: expressed as weekly amounts (and daily equivalents) for 24 nutrients.

Nutrient	Lower Limit (/wk)	Upper Limit (/wk)	Lower Limit (/day)	Upper Limit (/day)	Nutrient	Lower Limit (/wk)	Upper Limit (/wk)	Lower Limit (/day)	Upper Limit (/day)
ENERGY (kcal)	18894	20889	2699	2984	PYR (ug)	14000	28000	2000	4000
PROT (gm)	392.0	558.6	56.0	79.8	FOL (ug)	1400	2800	200	400
FAT-T (gm)	44.21	663.13	6.32	94.73	VIT-C (mg)	210	3500	30	500
SFA (gm)	0.00	221.04	0.00	31.58	VIT-A (iu)	35000	140000	5000	20000
PUFA (gm)	44.21	663.13	6.32	94.73	VIT-D (iu)	700	4200	100	600
P/S	1	2	1	2	VIT-E (mg)	63	700	9	100
CHO-T (gm)	2735.4	4476.1	390.8	639.4	CAL (gm)	5600	11200	800	1600
SUCR (gm)	0.0	746.02	0.0	106.57	PHOSP (mg)	5600	11200	800	1600
CHO-F (gm)	79.58	159.15	11.37	22.74	CA/P	0.8	1.2	0.8	1.2
THIA (mg)	9.94	19.89	1.42	2.84	MAG (mg)	2205	4410	315	630
NIAC (mg)	131.30	262.60	18.76	37.51	IRON (mg)	70	140	10	20
RIBO (mg)	11.94	23.87	1.71	3.41	POT (mg)	9800	19600	1400	2800

* Values for these constraints are derived from Appendix F.

\+ Standard subject was age 19 to 35, activity level code B, and 70 kg. body weight.

Two seven-day food-intake records were defined to represent the initial diet obtained from the standard male subject (Table 4.2). One record, called Standard Initial Diet 1 (SID-1), contained 3 items; the other, called Standard Initial Diet 2 (SID-2), contained 83 items. Table 4.3 compares the amounts of nutrients supplied by each of these diets with the upper and lower nutrient constraints.

Table 4.2 Standard Initial Diet 1 (SID-1) and Standard Initial Diet 2 (SID-2): Two seven-day food-intake records for a standard male subject, age 19 to 35, activity level code B, and 70 kilograms body weight.

GROUP-ITEM CODE #	FOOD ITEM	SID-1 (grams/week)	SID-2 (grams/week)
	ENTREE-DAIRY		
001-003	CHEDDER CHEESE...		182
001-004	COTTAGE CHEESE...		
001-005	CREAM CHEESE.....		
002-006	SOUR CREAM.......		
002-008	YOGHURT..........		
003-010	EGG..............		495
	ENTREE-CEREALS		
004-012	CORN CEREAL......		28
004-013	WHEAT CEREAL.....		
005-015	OATMEAL..........		270
005-016	WHEAT CEREAL.....		
006-017	PANCAKES.........		135
007-018	NOODLES..........		
007-019	SPAGHETTI........		
008-020	RICE, brown......	9375	
008-021	RICE, white......		
008-023	WHEAT GERM.......	280	
009-024	FRENCH BREAD.....		40
009-027	WHITE BREAD......		414
009-028	WHOLE WHEAT BREAD		
010-031	BISCUITS.........		70
010-032	HAMBURGER BUN....		46
010-033	MUFFIN...........		40
010-035	ENGLISH MUFFIN...		46
011-037	SALTINES.........		24
011-040	RYE KRISP........		
	ENTREE-MEATS		
012-041	BEEF, 30% fat....		170
012-042	BEEF, 20% fat....		85
012-043	BEEF, 15% fat....		170
012-046	PORK, lean cuts..		85
012-047	PORK, all hams...		43
012-048	BACON............		64
013-049	CHICKEN, steamed.		
013-051	CHICKEN, fried...		340

Table 4.2 (Continued)

014-055	FRIED FISH........		
014-056	BROILED FISH......		
014-058	OYSTERS...........		
014-062	SARDINES..........		
014-063	SHRIMP............		43
014-065	TUNA..............		60
015-067	LIVER.............		
017-069	FRANKFURTERS......		
017-070	FRESH SAUSAGES....		40
017-071	LIVERWURST........		
018-073	BEANS, dried......		
018-075	SOYBEANS..........		
019-076	ALMONDS...........		
019-077	CASHEW NUTS.......		15
019-079	PEANUT BUTTER.....		28
019-080	PEANUTS...........		120
019-081	PECANS............		
	ENTREE-VEGETABLES		
020-082	POTATOE, baked....		100
020-083	POTATOE, fried....		100
020-084	POTATOE, mashed...		200
020-085	SWEET POTATOE.....		180
021-089	BEANS, green......		65
021-091	BROCOLLI..........		63
021-092	CABBAGE...........		65
021-095	LETTUCE...........		180
021-098	PEAS..............		170
021-099	PEPPERS...........		
021-101	SPINACH...........		85
022-103	BEETS.............		80
022-104	CARROTS, cooked...		76
022-105	CARROTS, raw......		50
022-106	CORN..............		
022-111	TOMATOE...........		518
023-113	CUCUMBER..........		275
023-114	MUSHROOMS.........		
023-115	ONIONS............		8
024-116	SUCCOTASH.........		
025-117	OLIVES............		
025-118	PICKLES, sweet....		20
025-119	PICKLES, sour.....		34
	ENTREE-FATS		
026-121	LARD..............		5
026-124	SOYBEAN OIL.......		
027-125	BUTTER............		125

Table 4.2 (Continued)

028-127	CHEESE SAUCE......		
028-128	GRAVY.............		
029-132	MAYONNAISE........		105
029-133	SALAD DRESSING....		90
	BEVERAGES-DAIRY		
030-136	WHOLE MILK........		732
030-137	SKIM MILK.........	5658	
031-140	TABLE CREAM.......		195
031-141	WHIPPED CREAM.....		8
	BEVERAGES-FRUIT		
032-143	APPLE JUICE.......		
032-144	GRAPEFRUIT JUICE..		120
032-145	LEMON JUICE.......		5
032-148	ORANGE JUICE......		360
033-150	TOMATOE JUICE.....		
	BEVERAGES-MISC.		
034-151	COLA-TYPE.........		339
035-153	COFFEE............		2800
035-154	TEA...............		1600
036-155	BEER..............		3240
036-156	DISTILLED SPIRITS.		43
036-158	DRY WINES.........		400
	SOUPS		
037-160	CREAMED SOUPS.....		198
037-161	PEA SOUPS.........		200
037-163	MEAT + VEGIE SOUPS		
	DESSERTS-CEREALS		
038-166	COFFEE CAKE.......		75
038-168	FRUITCAKE.........		
038-170	ICED CAKES........		60
039-172	FRUIT PIES........		160
039-172	PUMPKIN PIES......		150
040-173	COOKIES...........		60
040-174	FRUIT COOKIES.....		
041-175	CAKE DOUGHNUTS....		60
041-177	DANISH PASTRY.....		38
	DESSERTS-DAIRY		
042-178	ICE-CREAM.........		270
042-179	SHERBERT..........		
043-181	PUDDINGS..........		185

Table 4.2 (Continued)

	DESSERTS-FRUIT		
044-183	APPLE.............		300
044-184	APPLESAUCE........		185
044-185	BANANA............		100
044-186	CANTALOUPE........		100
044-187	GRAPEFRUIT........		200
044-188	ORANGE............		150
044-192	PINEAPPLE.........		
045-193	DRIED FRUIT.......		
	DESSERTS-SWEETS		
047-195	HONEY.............		
047-197	SUGAR.............		105
048-198	JAMS..............		100
048-199	SYRUP.............		40
049-201	CHOCOLATE CANDY...		
049-202	MARSHMALLOW.......		
	MISCELLANEOUS		
051-205	POT PIES..........		227
063-217	SPAGHETTI + MEAT..		330
067-221	COCOA MIX.........		7
	Total Grams/Week..	15313	18871
	Total # of Items..	3	83

Table 4.3 Nutrient composition of SID-1 and SID-2 and the upper and lower nutrient constraints for a standard male subject.

Nutrient	Nutrient Constraints Minimum (/week)	Maximum (/week)	SID-1 Initial (/week)	SID-2 Initial (/week)
PROTEIN (gm)	392.00	713.82	512.54	558.60
CHO-T (gm)	2735.4	1872.4	2809.9	4476.1
T-FAT (gm)	44.209	981.39	92.428	663.13
KCAL	188899.	20195.	14210.	20889.
CHO-F (gm)	79.576	32.250	35.125	159.15
SFA (gm)	.0	367.46	5.6000	221.04
SUCR (gm)	.0	549.60	30.925	746.02
PUFA (gm)	44.209	543.42	22.400	663.13
VIT-A (iu)	35000.	69952.	0.0	.140E+06
VIT-D (iu)	700.00	1111.3	2319.8	4200.0
VIT-E (mg)	63.000	75.273	56.550	700.00
VIT-C (mg)	9.9470	10.292	16.329	19.894
RIBO (mg)	11.936	13.803	13.963	23.873
NIAC (mg)	131.30	178.25	148.67	262.60
VIT-B6 (ug)	15000.	12942.	20777.	28000.
FOLATE (mg)	1400.0	1460.9	2019.5	2800.0
POTAS (mg)	9800.0	22490.	17082.	19600.
CAL (mg)	5600.0	6137.3	8172.8	11200.
PHOSP (mg)	5600.0	11258.	15349.	11200.
IRON (mg)	70.000	120.08	73.195	140.00
MAG (mg)	2205.0	2386.5	4471.8	4410.0
CA/P	.8	.54514	.53245	1.2
P/S	1.0	1.4789	4.0000	2.0

4.2 Diet-Planning Model's Premises and Assumptions

A satisfactory procedure for dietary evaluation and suitable data on food composition and nutrient requirements were available for developing constraints to define dietary adequacy. However, no obvious procedure was available to define the relative acceptability of modifications in an initial dietary inventory. As previously mentioned (p.80), an extensive tradition does exist for hospital menu planning and Food Guide generated diets, but precise guidelines are not available for systematically developing individualized dietary prescriptions which are both nutritionally adequate and maximally acceptable to the client. Presumably the nature of this process is not fully understood.

In the absence of a detailed precedent which defines the relationship between an individual's nutrient-constrained food-choice and his or her initial dietary inventory, two major premises and related assumptions were used to define and operationalize the objective function.

4.2.1 The First Premise and Related Assumptions

The first major premise, for developing the model's objective function is that the client's most acceptable diet can be defined either by past consumption patterns -- namely, previous choice tends to define future choice -- or by a food plan identified as desirable by the client. In practice, past consumption may provide the better monitor of actual preference since it is the diet chosen under presently operating budgetary restrictions and long-term cultural and personal habits.

It is assumed that an individual identifies a diet's character by a complex of attributes. These attributes provide cues to distinguish one dietary pattern from another and an index to estimate the relative significance of dietary change. In this context, attributes are defined as measureable aspects of food or of behavior applied to foods, such as food taste, colour, ethnocultural pattern of food intake, nutrient content, menu function, food group, cost, serving frequency, preparation procedure, and a variety of food item relationships.

These attributes partition or categorize food substance into an array of parts and subparts; for example, into such typical categories as ingredients, food items, food groups, menu items, as well as less formal or personal dietary distinctions such as an individual's preferred items. Thus for each individual, an attribute map of considerable complexity can be envisioned. Depending on the attributes utilized by the individual, the map may correspond, more or less, to ethno-cultural patterns, familial patterns, and so on. Further, it should be noted that depending on the attributes considered, two diets may differ by one set of criteria but be alike by another.

The attribute map developed for the prototypical model is based, in part, on the examples of other authors (FAO/WHO 1949; Davenport 1964; Gue and Liggett 1966; Chandler and Perloff 1975; Canada 1977) who developed food classification schemes for various purposes. Only a limited number of illustrative attributes is considered for the prototypical model -- attributes presumably used by the average Canadian for identifying the similarities between food substances. This provisional assignment of attributes includes a definition of a standard item. These are mono-ingredient menu items which are low in complementarity requirements -- that is, items which do not require the coexistence of other items to ensure their palatability and acceptability -- and which can be assigned nutrient values from available literature. The other attributes considered are:

-generic terms of common usage such as cheeses, poultry, bread, and cultured milks;

-meal classification such as breakfast or lunch; food group assignments such as dairy products or fruit products; and

-some general physical characteristics including taste, colour, and physical state.

On this basis dietary items were partitioned into a hierarchical, attribute-group matrix based on the apparent similarities between defined items. The matrix elements created are discussed in Section 3.2.4 and described in Appendix G. Attributes not explicitly considered in developing the attribute map, such as pricing, are considered independent parameters for present purposes, even though their influence could affect the diets acceptability.

It is assumed that under conditions of change the map elements maintain their integrity. However, in some extreme situations, such as where radical dietary alterations are required, new attribute specifications may become apparent as food substance shifts from initial levels.

A vast number of attribute maps can be defined, each of which has a particular item list with its inherent interactional properties. The attribute map chosen, and the items and item groups thereby defined, are central to the eventual utility of such a model. The items and item groups selected will effect the accuracy and simplicity of the diet assessment procedure, the acceptability of the diet produced by the planning phase, and the outcome of communicating dietary modifications. For example, using a commodity list of palatable items for diet planning largely guarantees palatibility of the diet developed.

4.2.2 The Second Premise and Related Assumptions

The second major premise is that acceptable dietary modifications -- namely, the best approximation for compliance to nutritional prescriptions -- can be provided by determining the least-altered diet which meets nutrient constraints. The least-altered diet is presumably the best alternative, as perceived by the individual, to his or her presently chosen or preferred diet. Thus, the mathematical equation for determining the best alternative diet should reflect this concept.

The individual is assumed to perceive dietary change as a shift of food substance in his or her personal attribute map. The acceptability or perceived extent of this change then depends on the significance of changing each element of the map from its initial condition with respect to itself or to other elements. For the diet-planning model, the acceptability of this change is assumed to decrease as the square of the deviation from initial amounts for any element. Where unbounded, this produces a symmetrical quadratic curve centered around the initial amount of the element. This deviation is weighted by a penalty coefficient assigned to represent the relative significance of each attribute element deviating from initial amounts. The value assigned for this coefficient can be adjusted for a variety of hypotheses including client acceptability or preference, initial consumption levels, average serving size of items, or some other provisional pattern such as Canadian average consumption or nutritionist-recommended consumption levels. In the diet-planning model penalties are assigned to reflect initial consumption levels, consumed versus non-consumed status, and for hierarchical membership. Thus, the acceptability of a diet deviating from initial levels is defined as the summation of weighted squares of the difference between the amounts of the attribute elements in the initial and revised diets.

4.3 Observations of the Objective Function's Characteristics

4.3.1 Unconstrained Objective Function

The unconstrained objective function of the mathematical programming model (viz. no constraints on the nutrients) corresponds to the solution of a problem with an input diet which already satisfies nutrient constraints in all respects. The unconstrained solution allows the sum of weighted squared differences between items and item groups in the initial and revised diets to go to zero. This should result in a recommended diet identical to the initial diet -- the presumed ideal.

To verify this, a number of solutions for initial diets were obtained using the diet-planning model. These solutions (Table 4.4, 4.13) were developed from the SID-2 as the input diet and with a variety of objective functions (Eqns. 4.8, 4.9, 4.28) which incorporated different penalty coefficients, as described later in this text. The solutions for these diets were rerun using the same programs that generated them. As expected, in each case the original solution was identical to the rerun solution, allowing for rounding errors.

These observations illustrate, first, that each solution provided by the model is an optimal one, for the given input diet and nutrient constraints. Second, providing the diet satisfied the nutrient constraints, altering the penalty coefficients in the objective function for positive values of w_i and P_{jk} will not affect the outcome. The same phenomena would be expected with other objective functions incorporating the same theme of minimizing the deviation from the original diet, such as a linear objective function.

4.3.2 Constrained Objective Function

If the most acceptable diet for the client occurs when the sum of differences is allowed to go to zero, as with the unconstrained solutions, less acceptable diets would be those where, because of nutrient constraints, minimization towards zero is less successful. Presumably the larger the deviation the less acceptable the recommended diet will be for the client. The nature of this deviation and perhaps the relative acceptability of the outcome can be altered by modifying the characteristics of the objective function. The following material explores alterations of the objective function which produce different nutrient-constrained output profiles.

4.3.2.1 First Term: Shape of the Curve

The mathematical expression used in the model's objective function to minimize deviations of any item cluster from initial dietary levels, irrespective of specific concurrent deviations in other items, is the summed weighted square of differences between the amounts of item clusters in the initial and recommended diet, as follows:

$$\text{(4.1)} \qquad \text{minimize} \sum_{i=1}^{I} w_i \, (x_i - x_i^o)^2$$

This expression, corresponding to the first term of the objective function (Eqn. 3.2), describes a symmetrical quadratic curve centered at the initial consumption level, as shown in figure 4.1. As the difference between the initial and recommended values increases the quadratic objective intensifies the presumed unacceptability of this divergence. The choice of a quadratic curve is arbitrary, but it is the simplest nonlinear function which captures the essence of this phenomenon.

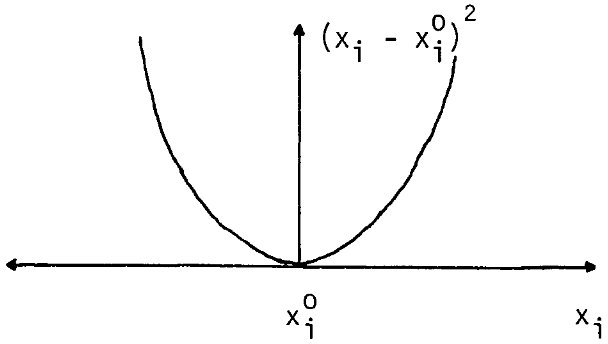

Figure 4.1 Graph of quadratic function reflecting penalties for deviation from initial consumption of food i.

A simpler alternative, but perhaps less realistic formulation, uses an objective that minimizes the absolute linear difference between the initial and recommended diet, as follows:

(4.2) $$\text{minimize} \quad \sum_{i=1}^{I} w_i \left(|x_i - x_i^o|\right)$$

In order to program this linear objective function (Eqn. 4.2), the formulation of the algorithm previously described (Eqns. 3.2-3.5) can be rewritten in a piece-wise linear form, as follows:

(4.3) $$\text{minimize} \quad \sum_{i=1}^{I} (w_i^+ x_i^+ + w_i^- x_i^-)$$

subject to

(4.4) $$x_i^+ - x_i^- = x_i - x_i^o \qquad (i = 1, 2, \ldots, I)$$

(4.5) $$m_q \geq \sum_{i=1}^{I} a_{qi} x_i \geq n_q \qquad (q = 1, 2, \ldots, Q)$$

(4.6) $$r_{uv} \geq \frac{\sum_{i=1}^{I} a_{ui} x_i}{\sum_{i=1}^{I} a_{vi} x_i} \geq t_{uv} \qquad (u,v = \text{any specified set of nutrient pairs})$$

(4.7) $$x_i,\ x_i^+,\ x_i^- \geqslant 0 \qquad (i = 1, 2, \ldots, I)$$

Where the newly defined terms are as follows:

x_i^+, x_i^- are, respectively, the positive and negative deviation of x_i from x_i^o.

$$x_i^+ = \begin{cases} (x_i - x_i^o) & \text{if } x_i - x_i^o > 0 \\ 0 & \text{otherwise} \end{cases}$$

$$x_i^- = \begin{cases} -(x_i - x_i^o) & \text{if } x_i - x_i^o < 0 \\ 0 & \text{otherwise} \end{cases}$$

That is, for each i at most one of x_i^+ and x_i^- can be positive.

w_i^+, w_i^- are the weighted penalty associated with the positive or negative deviation, respectively, of item cluster i from the original amount.

In more detail, the linear objective minimized the weighted positive and weighted negative deviation of item clusters from initial levels. Unlike the quadratic formulation the penalty associated with this deviation varies in direct proportion to the difference. The modelling constraints include, in addition to the nutrient constraints previously discussed, an equality constraint (Eqn. 4.4) which defines the positive or negative deviation of the revised diet to the initial diet, and a non-negativity constraint (Eqn. 4.7) which restricts entry of non-negative quantities of variables in the solution.

Although linearized solutions were not developed, with which the quadratic results could be directly compared, the two models would be expected to generate different solutions. Compared to the linear version the quadratic term introduces larger penalties as the prescribed diet deviates more widely from the initial diet, but smaller penalties for very small changes, as illustrated in Figure 4.2. Thus, the quadratic objective should moderate extreme fluctuations in any particular item by suppressing single large deviations between initial and revised values in favour of numerous smaller changes. The linear model should be less sensitive to large changes in specific items. Consequently, one can speculate that the linear model may provide dietary solutions with undesirably large changes in some single items, unless these changes are restricted by specific constraints on the amounts of these items. Correspondingly while the quadratic model moderates these extreme fluctuations, its solutions are more likely to include a large number of small decrements or increments. These small deviations may be considered as cosmetic problems which can be remedied by rounding values to the nearest usable portion, but consequently losing some accuracy of the minimization in the process. Alternatively, either constraints on minimum entry levels to prevent unusably small increments from zero, or integer programming, could be used to overcome this difficulty with more accuracy. However, the possibility of many items entering at minimum levels still exists unless specific restrictions are applied to the number of items entering the solution set.

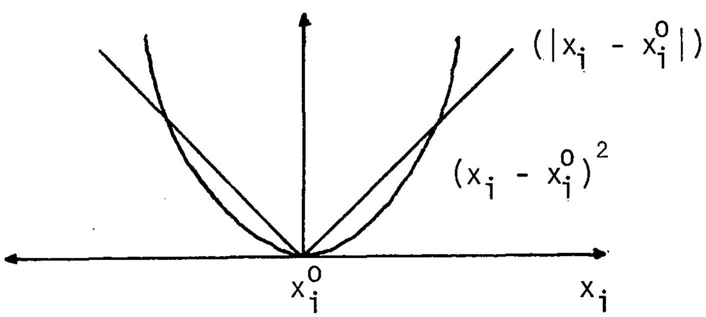

Figure 4.2 Graph of quadratic and linear functions reflecting penalties for deviation from initial consumption of food i.

4.3.2.2 First Term: Penalty Coefficient, w_i

The relative acceptability of change for different items should also be considered, in that alterations in the quantities of different dietary items may not be equally acceptable to the client. Consequently, in developing a recommended diet some items should be preferentially maintained at the initial amount whereas other items may be favourably altered to a greater or lesser extent. By altering the penalty-coefficient terms, w_i, of the equation which affect the relative slope of the exponential minimization curve, the value of increments for an item can be exaggerated or depressed.

The numerical value assigned to the penalty coefficient can correspond to one of, or the product of, a number of component values used to represent perceived acceptability. (i) The weighting coefficient can be normalized for initial comsumption level, that is, the inverse of the client's initial consumption of an item as determined from questionnaire data, as follows:

$$w_i \propto 1/(x_i^0 + \varepsilon)$$

Here a small increment, $\varepsilon > 0$, has been included in the denominator so that percentage change can still be represented when $x_i^0 = 0$. Values of $\varepsilon = 1$ and $\varepsilon = .01$ were chosen for test purposes, and are not intended to represent established values. Although the value chosen for ε is in some sense arbitrary, the values should be small enough so that solutions will not be appreciably altered at typical portion-sized values of x_i^0. At zero values of x_i^0, the small epsilon value of $\varepsilon = .01$ weights heavily against the entry of the item into the diet since percentage increase of x_i^0 would necessarily be large. Alternatively, initial consumption could be given a lesser weighting by using for example the inverse of the square root of initial consumption, as follows:

$$w_i \propto 1/\sqrt{(x_i^0 + \varepsilon)}$$

Thus, as consumption level increases the weighting penalty does not decrease proportionately.

(ii) Deviation could be normalized for standard serving size by weighting deviation with the inverse of serving size, as follows:

$$w_i \propto 1/\text{grams per serving of items cluster } i$$

Standard serving sizes are specified in Appendix A.

(iii) Further information which may be used in formulating a weighting coefficient to represent client willingness to deviate from original consumption includes: data on Canadian average consumption for normalizing deviations to Canadian norms; weighting coefficients obtained from nutritionists to massage solutions towards specific ends; or some other measure which may possibly represent an individual's acceptability dynamics, such as penalties to inhibit the entry of initially-zero item quantities. Two of the possible variations of the weighting coefficient, mentioned above, have been explicitly considered in the following material. These involve weighting deviation on the basis of initial consumption levels, and preferential weighting of consumed versus non-consumed items in the initial inventory.

4.3.2.2.1 Penalty Coefficient, w_i Based on Amount Consumed

The objective function already considered (Eqn. 4.1) can be defined to weight the squared deviation with a coefficient of 1 (Eqn. 4.9). A second approach is to weight deviations on the basis of initial consumption level, or to produce percentage squared deviations (Eqn. 4.9). The corresponding summed expressions for the objective functions are, as follows:

$$\text{(4.8)} \qquad \text{minimize} \sum_{i=1}^{I} 1\,(x_i - x_i^o)^2$$

$$\text{(4.9)} \qquad \text{minimize} \sum_{i=1}^{I} \frac{1}{(x_i^o + 1)^2}\,(x_i - x_i^o)^2$$

The value $\varepsilon = 1$ has been included in the denominator so that percentage change can be represented when $x_i = 0$, as previously discussed (p.145). Using the above objectives (Eqns. 4.8, 4.9), revised diets were developed from the two standard initial diets, SID-1 and SID-2, as shown in Table 4.4. The corresponding nutrient compositions are tabulated in Table 4.5.

Table 4.4 Revised diets developed from SID-1 and SID-2 using quadratic objective functions (Eqns. 4.8, 4.9)

GROUP-ITEM CODE #	FOOD ITEM	SID-1 (grams/week)* Initial	SID-1 Eqn.4.8	SID-1 Eqn.4.9	SID-2 (grams/week) Initial	SID-2 Eqn.4.8	SID-2 Eqn.4.9
	ENTREE-DAIRY						
001-003	CHEDDER CHEESE.			354	182	519	618
001-004	COTTAGE CHEESE.						
001-005	CREAM CHEESE...						
002-006	SOUR CREAM.....			13			
002-008	YOGHURT........						
003-010	EGG............				495	117	
	ENTREE-CEREALS						
004-012	CORN CEREAL....		203	203	28	210	108
004-013	WHEAT CEREAL...			50		221	88
005-015	OATMEAL........				270	187	207
005-016	WHEAT CEREAL...			14		24	21
006-017	PANCAKES.......				135		47
007-018	NOODLES........						
007-019	SPAGHETTI......						
008-020	RICE, brown....	9375	7773	3407		75	29
008-021	RICE, white....			25		39	11
008-023	WHEAT GERM.....	280					
009-024	FRENCH BREAD...			49	40	63	62
009-027	WHITE BREAD....			82	414	451	752
009-028	WHOLE WHEAT BREAD........			182		138	66
010-031	BISCUITS.......				70		2
010-032	HAMBURGER BUN..			82	46	83	73
010-033	MUFFIN.........				40		28
010-035	ENGLISH MUFFIN.			182	46	184	186
011-037	SALTINES.......			34	24	6	54
011-040	RYE KRISP......			50		221	88
	ENTREE-MEATS						
012-041	BEEF, 30% fat..				170		
012-042	BEEF, 20% fat..				85		
012-043	BEEF, 15% fat..				170		
012-046	PORK, lean cuts				85		
012-047	PORK, all hams.				43		
012-048	BACON..........				64		
013-049	CHICKEN, steamed						
013-051	CHICKEN, fried.				340		
014-055	FRIED FISH.....						
014-056	BROILED FISH...						

* Values rounded to the nearest grams/week, except values below 0.5 grams/week which are rounded to three decimal places.

Table 4.4 (Continued)

014-058	OYSTERS...........						
014-062	SARDINES..........						
014-063	SHRIMP............				43		
014-065	TUNA..............				60	22	37
015-067	LIVER.............						
017-069	FRANKFURTERS......						
017-070	FRESH SAUSAGES....				40		
017-071	LIVERWURST........					98	61
018-073	BEANS, dried......			126			25
018-075	SOYBEANS..........			33			
019-076	ALMONDS...........			73			
019-077	CASHEW NUTS.......				15		15
019-079	PEANUT BUTTER.....			88	28		
019-080	PEANUTS...........			79	120	10	43
019-081	PECANS............					85	112
	ENTREE-VEGETABLES						
020-082	POTATOE, baked....				100		
020-083	POTATOE, fried....				100		
020-084	POTATOE, mashed...			29	200	82	125
020-085	SWEET POTATOE.....			152	180	218	449
021-089	BEANS, green......		324	235	65	253	199
021-091	BROCOLLI..........		438	352	63	363	277
021-092	CABBAGE...........		199	178	65	180	175
021-095	LETTUCE...........			83	180	178	271
021-098	PEAS..............			355	170	572	924
021-099	PEPPERS...........		599	304		374	95
021-101	SPINACH...........		663	231	85	182	214
022-103	BEETS.............			163	80	159	178
022-104	CARROTS, cooked...		20	205	76	146	166
022-105	CARROTS, raw......			181	50	70	113
022-106	CORN..............			25		109	49
022-111	TOMATOE...........			59	518	448	577
023-113	CUCUMBER..........			39	275	210	230
023-114	MUSHROOMS.........			37			1
023-115	ONIONS............			117	8	119	48
024-116	SUCCOTASH.........			210		158	52
025-117	OLIVES............		1443	374		380	84
025-118	PICKLES, sweet....			93	20		20
025-119	PICKLES, sour.....			82	34		30
	ENTREE-FATS						
026-121	LARD..............		152	70	5		
026-124	SOYBEAN OIL.......			67			
027-125	BUTTER............		104	52	125	22	1
028-127	CHEESE SAUCE......			59			.003
028-128	GRAVY.............				72		28

Table 4.4 (Continued)

029-132	MAYONNAISE.......			27	105	21	44
029-133	SALAD DRESSING...		24	49	90	70	74
	BEVERAGES-DAIRY						
030-136	WHOLE MILK.......				732	632	
030-137	SKIM MILK........	5658	4197	1977			
031-140	TABLE CREAM......			13	195	93	60
031-141	WHIPPED CREAM....			23	8		
	BEVERAGES-FRUIT						
032-143	APPLE JUICE......			6			
032-144	GRAPEFRUIT JUICE.				120		
032-145	LEMON JUICE......				5		
032-148	ORANGE JUICE.....				360	174	
033-150	TOMATOE JUICE....			44			
	BEVERAGES-MISC.						
034-151	COLA-TYPE........				339	328	332
035-153	COFFEE...........				2800	2771	
035-154	TEA..............				1600	1572	306
036-155	BEER.............				3240	3229	4588
036-156	DISTILLED SPIRITS			39	43	34	41
036-158	DRY WINES........				400	324	159
	SOUPS						
037-160	CREAMED SOUPS...			17	198	145	155
037-161	PEA SOUPS........				200	99	128
037-163	MEAT + VEGIE SOUPS			20			3
	DESSERTS-CEREALS						
038-166	COFFEE CAKE......				75		11
038-168	FRUITCAKE........			22			
038-170	ICED CAKES.......				60		28
039-171	FRUIT PIES.......			97	160	219	307
039-172	PUMPKIN PIES.....			82	150	123	202
040-173	COOKIES..........				60		27
040-174	FRUIT COOKIES....		320	447		400	106
041-175	CAKE DOUGHNUTS...				60		
041-177	DANISH PASTRY....				38		
	DESSERTS-DAIRY						
042-178	ICE-CREAM........			21	270	195	137
042-179	SHERBERT.........			20		15	6
043-181	PUDDINGS.........			9	185	107	143
	DESSERTS-FRUIT						
044-183	APPLE............		328	222	300	485	1103
044-184	APPLESAUCE.......		118	120	185	284	419

Table 4.4 (Continued)

004-185	BANANA...........			38	100	44	174
044-186	CANTALOUPE.......			29	100		55
044-187	GRAPEFRUIT.......			27	200	135	159
044-188	ORANGE...........		206	122	150	159	226
044-192	PINEAPPLE........		113	90		37	18
045-193	DRIED FRUIT......				33		
	DESSERTS-SWEETS						
047-195	HONEY............			47		33	18
047-197	SUGAR............		8	68	105	109	151
048-198	JAMS.............		107	57	100	99	123
048-199	SYRUP............		332	94	40	129	95
049-201	CHOCOLATE CANDY..			33			
049-202	MARSHMALLOW......		8	68		44	11
	MISCELLANEOUS						
051-205	POT PIES.........				227	199	261
063-217	SPAGHETTI + MEAT.				330	179	107
067-221	COCOA MIX........			52	7		20
	Total Grams/Week.	15313	14679	12891	18871	19463	16831
	Total # of Items.	3	22	75	83	70	82
	# of Initial Items	3	2	2	83	53	61

Table 4.5 Nutrient composition of SID-1 and SID-2, and the revised diets developed using quadratic objective functions (Eqns. 4.8, 4.9)

Nutrient	Nutrient Minimum (/week)	Constraints Maximum (/week)	SID-1 Initial (/week)	SID-1 Eqn. 4.8 (/week)	SID-1 Eqn. 4.9 (/week)
PROTEIN(gm)	392.00	558.60	512.54	445.72	520.27
CHO-T(gm)	2735.4	4476.1	2809.9	3186.9	2808.5
T-FAT(gm)	44.209	663.13	92.428	511.45	663.13
KCAL	18899.	20889.	14210.	18899.	18899.
CHO-F(gm)	79.576	159.15	35.125	79.576	79.576
SFA(gm)	.0	221.04	5.6000	139.79	201.04
SUCR(gm)	.0	746.02	30.925	291.22	591.58
PUFA(gm)	44.209	663.13	22.400	279.59	372.48
VIT-A(iu)	35000.	140000.	0.0	78874.	92705.
VIT-D(iu)	700.00	4200.0	2319.8	1765.4	1612.1
VIT-E(mg)	63.000	700.00	56.550	63.000	97.001
VIT-c(mg)	210.00	3500.0	56.580	1440.5	1105.0
THIA(mg)	9.9470	19.894	16.329	11.669	11.831
RIBO(mg)	11.936	23.873	13.963	12.413	12.062
NIAC(mg)	131.30	262.60	148.67	131.30	131.30
VIT-B6(ug)	14000.	28000.	20777.	19814.	14000.
FOLATE(mg)	1400.0	2800.0	2019.5	1682.1	1649.3
POTAS(mg)	9800.0	19600.	17082.	19600.	19600.
CAL(mg)	5600.0	11200.	8172.8	8960.0	8960.0
PHOSP(mg)	5600.0	11200.	15349.	11200.	11200.
IRON(mg)	70.000	140.00	73.195	110.24	110.56
MAG(mg)	2205.0	4410.0	4471.8	3777.1	3401.8
CA/P	.8	1.2	0.53245	0.8000	0.8000
P/S	1.8	2.0	4.0000	2.0000	1.8528

Nutrient	Nutrient Minimum (/week)	Constraints Maximum (/week)	SID-1 Initial (/week)	SID-2 Eqn. 4.8 (/week)	SID-2 Eqn. 4.9 (/week)
PROTEIN(gm)	392.00	558.60	713.82	540.24	550.68
CHO-T(gm)	2735.4	4476.1	1872.4	2735.4	2735.4
T-FAT(gm)	44.209	663.13	981.39	612.94	638.72
KCAL	18899.	20889.	20195.	19239.	19754.
CHO-F(gm)	79.576	159.15	32.250	79.576	79.576
SFA(gm)	.0	221.04	367.46	221.04	221.04
SUCR(gm)	.0	746.02	549.60	746.02	746.02
PUFA(gm)	44.209	663.13	543.42	332.18	359.57
VIT-A(iu)	35000.	140000.	69952.	103460.	120730.
VIT-D(iu)	700.00	4200.0	1111.3	705.06	700.00
VIT-E(mg)	63.000	700.00	75.273	93.305	110.41
VIT-C(mg)	210.00	3500.0	886.80	1436.5	1224.0
THIA(mg)	9.9470	19.894	10.292	12.694	12.408
RIBO(mg)	11.936	23.873	13.803	13.931	13.479
NIAC(mg)	131.30	262.60	178.25	131.30	133.04
VIT-B6(ug)	14000.	28000.	12942.	14000.	14000.
FOLATE(mg)	1400.0	2800.0	1460.9	1745.2	1977.3
POTAS(mg)	9800.0	19600.	22490.	19600.	19600.
CAL(mg)	5600.0	11200.	6137.3	8960.0	8960.0
PHOSP(mg)	5600.0	11200.	11258.	11200.	11200.
IRON(mg)	70.000	140.00	120.08	140.00	136.93
MAG(mg)	2205.0	4410.0	2386.5	2875.1	2800.3
CA/P	.8	1.2	.54514	.80000	.80000
P/S	1.0	2.0	1.4789	1.5028	1.6267

Although each of these formulations produces revised diets which are optimal solutions in the sense that they minimize total squared deviation, the revised diets are expected to be different because of the different penalty coefficients, w_i. Using Equation 4.9, the size of the absolute deviation of items from initial levels should increase as initial consumption level rises. In contrast, the absolute deviation associated with different initial amounts should not vary with the equation using direct squared deviation (Eqn. 4.8), since the penalty coefficient does not incorporate a term for initial consumption levels.

This phenomenon is illustrated in Table 4.6 which compares the average absolute deviation of items in the revised diets from their initial consumption levels. Where the penalty coefficient includes a term for initial consumption (Eqn. 4.9), the average absolute deviation rises from 61 grams at a consumption level of 0 grams/week to 5968 grams at a consumption of 9351-9400 grams/week for the SID-1 revised diet, and from 22 grams at a consumption level of 0 grams/week to 2800 grams at a consumption of 2751-2800 grams/week for the SID-2 revised diet. This extent of rise is not evident with the other equation (Eqn. 4.8).

The average absolute deviation of items at each initial consumption level is not exactly proportional to the penalty weighting applied. If they were, for example, the objective using direct squared deviation (Eqn. 4.8) would be expected to produce the same average absolute deviation for items at each of the initial consumption levels, but it does not. This discrepancy is caused by the unequal distribution of nutrients across items. Those which are efficient sources of nutrients for a given situation deviate more widely. If all items made the same nutrient contribution, the quadratic objectives would spread deviations over all items in exact proportions to the penalty coefficient's relative weighting, in order to satisfy nutrient constraints. On the other hand, if each item contributed only one unique nutrient, the solution outcome would be insensitive to different weighting coefficients. Each item would be a most efficient source of one particular nutrient.

Table 4.6 Average absolute deviation from initial consumption levels for items in revised diets developed from SID-1 and SID-2 using quadratic objective functions (Eqns. 4.8, 4.9)

Initial Consumption (grams/item)	Average Absolute Deviation From SID-1			Average Absolute Deviation From SID-2		
	# of Items	Eqn. 4.8 (grams)	Eqn. 4.9 (grams)	# of Items	Eqn. 4.8 (grams)	Eqn.4.9 (grams)
0	124	46	61	44	56	22
0-50				22	43	32
51-100				22	82	77
101-150				8	74	81
151-200				14	129	191
201-250				1	28	34
251-300	1	280	280	4	102	261
301-350				3	167	190
351-400				2	131	303
401-450				1	37	338
451-500				1	378	495
501-550				1	70	59
701-750				1	100	732
1551-1600				1	28	1294
2751-2800				1	29	2800
3201-3250				1	11	1348
5651-5700	1	1461	3681			
9351-9400	1	1602	5968			

The different treatment of deviations by these two objective functions results in marked differences in the solution profiles. With respect to the number of items contained in the diets developed from SID-1 (foot of Table 4.4), both objectives have retained two of the three original items. However, the objective function using percentage squared deviation (Eqn. 4.9) has added 73 new items to the diet for a total of 75 items in the revised diet, whereas the other objective (Eqn. 4.8) has only added 20 new items for a total of 22 items in the revised diet. Thus, each objective has enlisted new items, but the percentage formulation has enlisted a much greater number.

This difference is to be expected since the percentage formulation applies a heavy penalty load for deviation of small-quantity items in the initial diet compared to an equivalent deviation in a large-quantity item, while the other formulation does not. Thus, the efficiency of any small-quantity item to supply nutrients to satisfy the constraints is quickly exhausted with the percentage formulation. The consequence is that a longer sequence of alternate efficient sources must be incorporated into the revised diet based on minimum percentage deviation, if these cannot be claimed from items already included in the diet.

With respect to the number of items in the diets developed from SID-2, the percentage formulation has retained 61 of the original 83 items and added 21 new items for a total revised solution of 82 items. The solution using direct squared deviation has retained 53 of the original 83 items and added 17 items for a total revised solution of 70 items.

Unlike the revised diets developed from the SID-1, those developed from SID-2 do not demonstrate such a large difference in the number of new items entering the solution. In fact, the revised diet developed from SID-2 using the percentage formulation enlists only a few more new items than the revised diet based on direct squared deviation -- 17 and 21, respectively, as compared to 20 and 73, for the SID-1 solutions. The change in relative proportion of new-item entry for the two formulations is due to the availability of additional consumed items in the SID-2. In this instance, additional items have provided the percentage formulation with a relatively greater number of efficient nutrient sources, and consequently relatively fewer new items have entered the solution. Because larger-quantity items can deviate widely compared to small-quantity items with the percentage formulation, less concentrated sources of nutrients can be used efficiently to meet the constraints provided these items are present in the diet in appropriate amounts.

Although, in terms of the number of items, there is not a great disparity between the revised diets developed from SID-2 with these two formulations, as compared to those from SID-1, differences are apparent. The revised diet developed from SID-2 by the percentage formulation has more liberally included both original items -- 61 as compared with 53 from the direct formulation --, and new items -- 21 as compared with 17 from the direct formulation. It is not clear that the percentage formulation should necessarily incorporate more items in revised solutions developed with every diet. Both formulations, direct and percentage squared deviation are quadratic and hence tend to exhaust the efficiency of any particular item to act as an efficient nutrient source. This spreads deviation over items. In this instance, however, the nutrient distribution over items and the quantities of the items consumed has resulted in the percentage formulation incorporating a greater number of both non-consumed and consumed items in the revised diet.

The percentage formulation does not necessarily have a conceptual advantage over the direct formulation. The formulation incorporating percentage squared deviation provides the apparent advantage of adjusting the unit value of deviations relative to their initial consumption level. Thus, regardless of the initial amount consumed, the penalty associated with decreasing to zero or doubling in amount is the same. Viewed one way, with the percentage formulation small-quantity items are not sacrificed to meet nutrient constraints while large-quantity items are preferentially maintained, as is the case with the formulation using direct squared deviation. On the other hand, the formulation with percentage squared deviation implies that the penalty for seemingly large deviations in the quantities of large-quantity items should be penalized the same as an equal-percentage, but relatively small, absolute change in small-quantity items.

4.3.2.2.2 Penalty Coefficient, w_i, Based on Initial Consumption

Penalty coefficients were chosen to differentially penalize initially consumed versus non-consumed items, as follows:

$$\text{(4.10)} \quad \text{minimize} \sum_{i=1}^{I} w_i(x_i) \left(_i - x_i^0 \right)^2 \quad \text{where } w_i(x_i) = \begin{cases} 100 \text{ if } x_i^0 = 0 \\ 1 \text{ if } x_i^0 > 0 \end{cases}$$

$$\text{(4.11)} \quad \text{minimize} \sum_{i=1}^{I} w_i(x_i) \left(x_i - x_i^0 \right)^2 \quad \text{where } w_i(x_i) = \begin{cases} 10{,}000 \text{ if } x_i^0 = 0 \\ 1 \text{ if } x_i^0 > 0 \end{cases}$$

$$\text{(4.12)} \quad \text{minimize} \sum_{i=1}^{I} \frac{1}{(x_i^0 + .01)^2} \left(x_i - x_i^0 \right)^2$$

For the formulations using direct squared deviation (Eqns. 4.10, 4.11), penalty weightings of 100 and 10,000, respectively, were applied to items not consumed in the client's original diet. For the formulation using percentage squared deviation (Eqn. 4.12), a penalty value of 10,000 was applied to non-consumed items by defining epsilon as .01 over all items. Although this is not strictly equivalent to the expression:

$$\text{minimize} \sum_{i=1}^{I} \frac{10{,}000}{(x_i^o + 1)^2} (x_i - x_i^o)^2;$$

for originally consumed items, the error introduced for portion-sized items should be small. Revised diets (Table 4.7, 4.8) were developed from SID-1 and SID-2 using these objectives (Eqns. 4.10-4.12). The nutrient composition of the initial and revised diets are tabulated in Tables 4.9 and 4.10.

Table 4.7 Revised diets developed from SID-1 using quadratic objective functions (Eqns. 4.9, 4.12).

GROUP-ITEM CODE #	FOOD ITEM	SID-1 (grams/week)* Initial	Eqn. 4.9	Eqn. 4.12
	ENTREE-DAIRY			
001-003	CHEDDER CHEESE...		354	358
001-004	COTTAGE CHEESE...			
001-005	CREAM CHEESE.....			
002-006	SOUR CREAM.......		13	14
002-008	YOGHURT..........			
003-010	EGG..............			
	ENTREE-CEREALS			
004-012	CORN CEREAL......		203	202
004-013	WHEAT CEREAL.....		50	51
005-015	OATMEAL CEREAL...			
005-016	WHEAT CEREAL.....		14	15
006-017	PANCAKES.........			
007-018	NOODLES..........			
007-019	SPAGHETTI........			
008-020	RICE, brown......	9375	3407	3403
008-021	RICE, white......		25	25
008-023	WHEAT GERM.......	280		
009-024	FRENCH BREAD.....		49	49
009-027	WHITE BREAD......		82	82
009-028	WHOLE WHEAT BREAD		182	182
010-031	BUSCUITS.........			
010-032	HAMBURGER BUN....		82	82
010-033	MUFFIN...........			
010-035	ENGLISH MUFFIN...		182	182
011-037	SALTINES.........		34	34
011-040	RYE KRISP........		50	51
	ENTREE-MEATS			
012-041	BEEF, 30% fat....			
012-042	BEEF, 20% fat....			
012-043	BEEF, 15% fat....			
012-046	PORK, lean cuts..			
012-047	PORK, all hams...			
012-048	BACON............			
013-049	CHICKEN, steamed.			
013-051	CHICKEN, fried...			
014-055	FRIED FISH.......			
014-056	BROILED FISH.....			
014-058	OYSTERS..........			

* Values rounded to the nearest gram/week.

Table 4.7 (Continued)

014-062	SARDINES.........			
014-063	SHRIMP...........			
014-065	TUNA.............			
015-067	LIVER............			
017-069	FRANKFURTERS.....			
017-070	FRESH SAUSAGES...			
017-071	LIVERWURST.......			
018-073	BEANS, dried.....		126	126
018-075	SOYBEANS.........		33	33
019-076	ALMONDS..........		73	74
019-077	CASHEW NUTS......			
019-079	PEANUT BUTTER....		88	88
019-080	PEANUTS..........		79	79
019-081	PECANS...........			
	ENTREE-VEGETABLES			
020-082	POTATOE, baked...			
020-083	POTATOE, fried...			
020-084	POTATOE, mashed...		29	30
020-085	SWEET POTATOE....		152	152
021-089	BEANS, green.....		235	235
021-091	BROCOLLI.........		352	352
021-092	CABBAGE..........		173	173
021-095	LETTUCE..........		83	84
021-098	PEAS.............		355	354
021-099	PEPPERS..........		304	304
021-101	SPINACH..........		231	232
022-103	BEETS............		163	162
022-104	CARROTS, cooked..		205	204
022-105	CARROTS, raw.....		181	181
022-106	CORN.............		25	26
022-111	TOMATOE..........		59	59
023-113	CUCUMBER.........		39	39
023-114	MUSHROOMS........		37	37
023-115	ONIONS...........		117	117
024-116	SUCCOTASH........		210	210
025-117	OLIVES...........		374	373
025-118	PICKLES, sweet...		93	93
025-119	PICKLES, sour....		82	82
	ENTREE-FATS			
026-121	LARD.............		70	69
026-124	SOYBEAN OIL......		67	66
027-125	BUTTER...........		52	52
028-127	CHEESE SAUCE.....		59	60
028-128	GRAVY............			

Table 4.7 (Continued)

029-132	MAYONNAISE........		27	27
029-133	SALAD DRESSING....		49	49
	BEVERAGES-DAIRY			
030-136	WHOLE MILK........			1
030-137	SKIM MILK.........	5658	1977	1936
031-140	TABLE CREAM.......		13	14
031-141	WHIPPED CREAM.....		23	23
	BEVERAGES-FRUIT			
032-143	APPLE JUICE.......		6	6
032-144	GRAPEFRUIT JUICE..			
032-145	LEMON JUICE.......			
032-148	ORANGE JUICE......			
033-150	TOMATOE JUICE.....		44	44
	BEVERAGES-MISC.			
034-151	COLA-TYPE.........			
035-153	COFFEE............			
035-154	TEA...............			
036-155	BEER..............			
036-156	DISTILLED SPIRITS.		39	39
036-158	DRY WINES.........			
	SOUPS			
037-160	CREAMED SOUPS.....		17	18
037-161	PEA SOUPS.........			
037-163	MEAT + VEGIE SOUPS		20	20
	DESSERTS-CEREALS			
038-166	COFFEE CAKE.......			
038-168	FRUITCAKE.........		22	22
038-170	ICED CAKES........			
039-171	FRUIT PIES........		97	97
039-172	PUMPKIN PIES......		82	82
040-173	COOKIES...........			
040-174	FRUIT COOKIES.....		447	445
041-175	CAKE DOUGHNUTS....			
041-177	DANISH PASTRY.....			
	DESSERTS-DAIRY			
042-178	ICE-CREAM.........		21	22
042-179	SHERBERT..........		20	20
043-181	PUDDINGS..........		9	10
	DESSERTS-FRUIT			
044-183	APPLE.............		222	221
044-184	APPLESAUCE........		120	119

Table 4.7 (Continued)

044-185	BANANA............		38	39
044-186	CANTALOUPE........		29	30
044-187	GRAPEFRUIT........		27	27
044-188	ORANGE............		122	122
044-192	PINEAPPLE.........		90	91
045-193	DRIED FRUIT.......		33	35
	DESSERTS-SWEETS			
047-195	HONEY.............		47	47
047-197	SUGAR.............		68	68
048-198	JAMS..............		57	57
048-199	SYRUP.............		94	94
049-201	CHOCOLATE CANDY...		33	34
049-202	MARSHMALLOW.......		68	68
	MISCELLANEOUS			
051-205	POT PIES..........			
063-217	SPAGHETTI + MEAT..			
067-221	COCOA MIX.........		52	54
	Total Grams/Week..	15313	12891	12862
	Total # of Items..	3	75	76
	# of Initial Items	3	2	2

Table 4.8 Revised diets developed from SID-2 using quadratic objective functions(Eqns. 4.8-4.12)

GROUP-ITEM CODE #	FOOD ITEM	SID-2 (grams/week)* Initial	Eqn.7.8	Eqn.4.10	Eqn.4.11	Eqn.4.9	Eqn.4.12
	ENTREE-DAIRY						
001-003	CHEDDER CHEESE	182	519	553	546	618	696
001-004	COTTAGE CHEESE						
001-005	CREAM CHEESE...						
002-006	SOUR CREAM.....						
002-008	YOGHURT........						
003-010	EGG...........	+ 495	117	6			
	ENTREE-CEREALS						
004-012	CORN CEREAL....	28	210	421	431	108	42
004-013	WHEAT CEREAL...		221	13	0.14	38	0.03
005-015	OATMEAL.......	270	187	185	174	207	125
005-016	WHEAT CEREAL...		24	3	0.03	21	0.01
006-017	PANCAKES.......	135				47	
007-018	NOODLES........						
007-919	SPAGHETTI......						
008-020	RICE, brown....		75	6	0.06	29	0.01
008-021	RICE, white....		39	1	0.02	11	0.01
008-021	WHEAT GERM.....			3	0.04		
009-024	FRENCH BREAD...	40	63	50	44	62	44
009-027	WHITE BREAD....	414	451	370	357	752	981
009-028	WHOLE WHEAT BREAD........		138	5	0.05	66	0.02
010-031	BISCUITS.......	70				2	16
010-032	HAMBURGER BUN..	46	83	2		73	53
010-033	MUFFIN.........	40				28	34
010-035	ENGLISH MUFFIN.	56	184	467	478	186	95
011-037	SALTIMES.......	24	6	146	147	54	27
011-049	RYE KRISP......		221	13	0.14	88	0.01
	ENTREE-MEATS						
012-041	BEEF, 30% fat..	170					
012-042	BEEF, 20% fat..	85					
012-043	BEEF, 15% fat..	170					
012-046	PORK, lean cuts	185					
012-047	PORK, all hams.	43					21
012-048	BACON.........	64					

* Values rounded to the nearest gram/week, except values below 0.5 grams/week which are rounded to two decimal places.

Table 4.8 (Continued)

013-049	CHICKEN, steamed			1	0.01		
013-051	CHICKEN, fried.	350					
014-055	FRIED FISH.....						
014-056	BROILED FISH...						
014-058	OYSTERS........						
014-062	SARDINES.......						
014-063	SHRIMP.........	43					17
014-065	TUNA...........	60	22	167	211	37	67
015-067	LIVER..........			2	0.03		
017-069	FRANKFURTERS...						
017-070	FRESH SAUSAGES...	40					5
017-071	LIVERWURST.....		98	22	0.03	61	0.03
019-076	ALMONDS........						
019-077	CASHEW NUTS....	15		115	133	15	15
019-079	PEANUT BUTTER..	28					20
019-080	PEANUTS........	120	10			43	36
019-081	PECANS.........		85	19	0.21	112	0.04
	ENTREE-VEGETABLES						
020-082	POTATOE, baked..	100					7
020-083	POTATOE, fried.	100					
020-084	POTATOE, mashed	200	82			125	84
020-085	SWEET POTATOE..	180	218	324	387	449	539
021-089	BEANS, green...	65	253	368	368	199	141
021-091	BROCOLLI.......	63	363	683	708	277	181
021-092	CABBAGE........	65	180	377	401	175	130
021-095	LETTUCE........	190	178	97	81	271	321
021-098	PEAS...........	178	572	1134	1169	924	1247
021-099	PEPPERS........		374	11	0.11	95	0.04
021-101	SPINACH........	85	182	202	212	214	187
022-103	BEETS..........	80	158	165	153	178	151
022-104	CARROTS, cooked	76	146	11		166	137
022-105	CARROTS, raw....	50	70	44	34	113	77
022-106	CORN...........		109	9	0.10	49	0.02
022-111	TOMATOE........	518	448	327	310	577	724
023-113	CUCUMBER.......	275	210	52	29	230	198
023-114	MUSHROOMS......					1	0.00
023-115	ONIONS.........	8	119	357	381	48	9
024-116	SUCCOTASH......		159	4	0.04	52	0.02
025-117	OLIVES.........		380	7	0.07	84	0.03
025-118	PICKLES, sweet.	20				20	21
025-119	PICKLES, sour..	34				30	33
	ENTREE-FATS						
026-121	LARD...........	5		63	78		5
026-124	SOYBEAN OIL....						
027-125	BUTTER.........	125	22	29	29	1	16

Table 4.8 (Continued)

028-127	CHEESE SAUCE...					0.29	
028-128	GRAVY..........	72				28	46
029-132	MAYONNAISE.....	105	21			44	50
029-133	SALAD DRESSING.	30	70	65	65	74	78
	BEVERAGES-DAIRY						
030-136	WHOLE MILS.....	732	632	446	421		
030-137	SKIM MILK......						
031-140	TABLE CREAM.....	185	93			60	
031-141	WHIPPED CREAM..	8					8
	BEVERAGES-FRUIT						
032-143	APPLE JUICE....						
032-144	GRAPEFRUIT JUICE	120					
032-145	LEMON JUICE....	5					5
032-148	ORANGE JUICE...	360	174				
033-150	TOMATOE JUICE..						
	BEVERAGES-MISC.						
034-151	COLA-TYPE......	339	328	350	350	332	347
035-153	COFFEE.........	2800	2771	2711	2705		
035-154	TEA............	1600	1572	1516	1508	306	
036-155	BEER...........	3240	3229	3363	3384	4588	7878
036-156	DISTILLED SPIRITS	43	34	28	28	41	42
036-158	DRY WINES.......	400	324	241	235	154	
	SOUPS						
037-160	CREAMED SOUPS...	198	145	25	7	155	112
037-161	PEA SOUPS.......	200	99	37	22	128	81
037-163	MEAT + VEGIE SOUP					3	0.00
	DESSERTS-CEREALS						
038-166	COFFEE CAKE.....	75				11	27
038-168	FRUITCAKE.......						
038-170	ICED CAKES.......	60				28	43
039-171	FRUIT PIES......	160	219	346	352	307	361
039-172	PUMPKIN PIES....	150	123	45	18	202	224
040-173	COOKIES.........	60		60	58	27	42
040-174	FRUIT COOKIES....		400	9	0.09	106	0.04
041-175	CAKE COUGHNUTS...	60					22
051-177	DANISH PASTRY....	38					26
	DESSERTS-DAIRY						
042-178	ICE-CREAM........	270	195	85	66	137	9
042-179	SHERBERT.........		15	1	0.01	6	0.00
043-181	PUDDINGS.........	185	107	35	19	143	116

Table 4.8 (Continued)

	DESSERTS-FRUIT						
044-183	APPLE............	300	485	644	643	1105	1920
044-184	APPLESAUSE.......	185	284	423	430	419	552
044-185	BANANA...........	100	44	370	430	174	184
044-186	CANTALOUPE.......	100				55	66
044-187	GRAPEFRUIT.......	200	135			159	137
044-188	ORANGE...........	150	159	43	24	226	253
044-192	PINEAPPLE........		37	1	0.01	18	0.01
045-193	DRIED FRUIT......						
	DESSERTS-SWEETS						
047-195	HONEY............		33	2	0.02	18	0.01
047-197	SUGAR............	105	109	190	197	151	185
048-198	JAMS.............	100	99	157	162	123	136
048-199	SYRUP............	40	129	283	312	95	54
049-201	CHOCOLATE CANDY..						
049-202	MARSHMALLOW......		44	2	0.03	11	0.01
	MISCELLANEOUS						
051-205	POT PIES.........	227	199	299	312	261	286
063-217	SPAGHETTI + MEAT.	330	179	45	28	107	
067-221	COCOA MIX........	7				20	8
	Total Grams/Week.	18871	18463	18748	18748	16831	19850
	Total # of Items.	83	70	70	67	82	86
	# of Initial Items	83	53	50	47	61	66
	# of New Items...		17	20	20	21	20

Table 4.9 Nutrient composition of SID-1, and the revised diets developed using quadratic objective functions (Eqns. 4.9, 4.12).

Nutrient	Nutrient Minimum (/week)	Constraints Maximum (/week)	SID-1 Initial (/week)	SID-1 Eqn. 4.9 (/week)	SID-1 Eqn. 4.12 (/week)
PROTEIN(gm)	392.00	558.60	512.54	520.27	520.46
CHO-T (gm)	2735.4	4476.1	2809.9	2808.5	2808.9
TFAT(gm)	44.209	663.13	92.428	663.13	663.13
KCAL	18899.	20889.	14210.	18899.	18899.
CHO-F(gm)	79.576	159.15	35.125	79.576	79.576
SFA(gm)	.0	221.04	5.6000	201.04	20.179
SUCR(gm)	.0	746.02	30.925	591.58	593.21
PUFA(gm)	44.209	663.13	22.400	372.48	371.84
VIT-A(iu)	35000.	.14000E+06	0.0	92705.	92840.
VIT-D(iu)	700.00	4200.0	2319.8	1612.1	1617.1
VIT-E(mg)	63.000	700.00	56.550	97.001	97.018
VIT-C(mg)	210.00	3500.0	56.580	1105.0	1105.3
THIA(mg)	9.9470	19.894	16.329	11.831	11.824
RIBO(mg)	11.936	23.873	13.963	12.062	12.039
NIAC(mg)	131.30	262.60	148.67	131.30	131.30
VIT-B6(ug)	14000.	28000.	20777.	14000.	14000.
FOLATE(mg)	1400.0	2800.0	2019.5	1649.3	1649.6
POTAS(mg)	9800.0	19600.	17082.	19600.	19600.
CAL(mg)	5600.0	11200.	8172.8	8960.0	8960.0
PHOSP (mg)	5600.0	11200.	15349.	11200.	11200.
IRON(mg)	70.000	140.00	73.195	110.56	110.72
MAG(mg)	2205.0	4410.0	4471.8	3401.8	3408.1
CA/P	.8	1.2	0.53245	0.8000	0.80000
P/S	1.0	2.0	4.0000	1.8528	1.8427

Table 4.10 Nutrient composition of SID-2, and the revised diets developed using quadratic objective functions (Eqns. 4.8-4.12)

Nutrient	Nutrient Minimum (/week)	Constraints Maximum (/week)	SID-2 Initial (/week)	SID-2 Eqn. 4.8 (/week)	SID-2 Eqn. 4.10 (/week)	Eqn.4.11 (/week)
PROTEIN(gm)	392.00	558.60	713.82	540.24	558.60	558.60
CHO-T(gm)	2735.4	4476.1	1872.4	2735.4	2735.4	2735.4
T-FAT(gm)	44.209	663.13	981.39	612.94	575.66	572.11
KCAL	18899.	20889.	20195.	19239.	19026.	18999.
CHO-F(Gm)	79.576	159.15	32.250	79.576	79.576	79.576
SFA(gm)	.0	221.04	367.46	221.04	221.04	221.04
SUCR(gm)	.0	746.02	549.60	746.02	746.02	746.02
PUFA(gm)	44.209	663.13	543.42	332.18	308.42	305.72
VIT-A(iu)	35000.	140000.	69952.	103460.	94146.	91999.
VIT-D(iu)	700.00	4200.0	1111.3	705.06	896.00	980.41
VIT-E(mg)	63.000	700.00	75.273	93.305	102.51	101.04
VIT-C(mg)	210.00	3500.0	886.80	1436.5	1361.2	1382.6
THIA(mg)	9.9470	19.894	10.292	12.694	11.699	11.452
RIBO(mg)	11.936	23.873	13.803	13.931	12.421	11.936
NIAC(mg)	131.30	262.60	178.25	131.30	137.02	139.70
BIT-B6(ug)	14000.	28000.	12942.	14000.	14000.	14000.
FOLATE(mg)	1400.0	2800.0	1460.9	1745.2	1755.0	1718.1
POTAS(mg)	9800.0	19600.	22490.	19600.	19600.	19600.
CAL(mg)	5600.0	11200.	6137.3	8960.0	8419.0	8266.1
PHOSP(mg)	5600.0	11200.	11258.	11200.	10524.	10333.
IRON(mg)	70.000	140.00	120.08	140.00	140.00	140.00
MAG(mg)	2205.0	4410.0	2386.5	2875.1	2772.8	2766.9
CA/P	.8	1.2	.54514	.80000	.80000	.80000
P/S	1.0	2.0	1.4789	1.5028	1.3953	1.383

Nutrient	Nutrient Minimun (/week)	Constraints Maximum (/week)	SID-2 Initial (/week)	SID-2 Eqn. 4.9 (/week)	SID-2 Eqn. 4.12 (/week)
PROTEIN(gm)	392.00	558.60	713.82	550.68	538.24
CHO-T(gm)	2735.4	4476.1	1872.4	2735.4	2735.4
T-FAT(gm)	44.209	663.13	981.39	636.72	586.78
KCAL	18899.	20889.	20195.	19754.	20075.
CHO-F(gm)	79.576	159.15	32.250	79.576	79.576
SFA(gm)	.0	221.05	367.46	221.04	221.04
SUCR(gm)	.0	746.02	549.60	746.02	746.02
PUFA(gm)	44.209	663.13	543.42	359.57	310.87
VIT-A(iu)	35000.	140000.	69952.	120730.	121670.
VIT-D(iu)	700.00	4200.0	1111.3	700.0	700.00
VIT-E(mg)	63.000	700.00	75.273	110.41	88.360
VIT-C(mg)	210.00	3500.0	886.80	1224.0	1145.9
THIA(mg)	9.9470	19.894	10.292	12.408	11.339
RIBO(mg)	11.936	23.873	13.803	13.479	13.373
NIAC(mg)	131.30	262.60	178.25	133.05	148.24
VIT-B6(ug)	14000.	28000.	12942.	14000.	14000.
FOLATE(mg)	1400.0	2800.0	1460.9	1977.3	1939.2
POTAS(mg)	9800.0	19600.	22490.	19600.	19600.
CAL(mg)	5600.0	11200.	6137.3	8960.0	8960.0
PHOSP(mg)	5600.0	11200.	11258.	11200.	11200.
IRON(mg)	70.000	140.00	120.08	136.93	128.56
MAG(mg)	2205.0	4410.0	2386.5	2800.3	2702.6
CA/P	.8	1.2	.54514	.80000	.80000
P/S	1.0	2.0	1.4789	.80000	1.4064

The solution dynamics for formulations which selectively penalize change in non-consumed versus consumed items are analogous to those previously discussed which penalize on the basis of percentage or absolute deviation. In this instance, however, the penalty curves slope is further altered as a function of the penalty weighting applied to selected items. If a change in a particular item is heavily or lightly penalized, the slope of the penalty curve is proportionately increased or decreased, respectively. Consequently, the size of the average absolute deviation for an item tends to decrease as the penalty weighting increases, and increase as the penalty decreases. This phenomenon is illustrated in Table 4.12 which compares the average absolute deviation from initial consumption levels for each of the revised diets developed from SID-2. As the penalty applied to non-consumed items increases relative to that for consumed items, the average absolute deviation of non-consumed items decreases. For example, consider the objective functions using direct squared deviation (Eqns. 4.8, 4.10, 4.11). With ehese the absolute deviation from zero for non-consumed items has decreased from 56 to 3 to 0.03 with penalty ratios for non-consumed/consumed items of 1/1, 100/1, and 10,000/1, respectively. Interestingly, the effect is roughly proportional to the increase in penalty assignment. Similarly, for the percentage formulations (Eqns. 4.9, 4.12) an increase in relative penalty on non-consumed items of 1 to 10,000 has reduced the average absolute deviation from 22 to 0.01. The decreased deviation in non-consumed items has been reflected by a reasonably consistent increase in the deviation of the categories of consumed items, as shown in Table 4.12.

Unlike the revised diets developed from SID-2, those developed from SID-1 (Table 4.11) using the percentage formulation (Eqns. 4.9, 4.12) are virtually insensitive to increased penalty weightings on non-consumed items. This different outcome can be explained by the large number of non-consumed items in the initial diet relative to consumed items. The uniform increase of the penalty over all non-consumed items does not appreciably alter the solution dynamics among the vast majority of items in the diet. Also, it is apparent that the utility of the three initially-consumed items to supply nutrients has not changed much, even with the 10,000 fold increase in penalty on the non-consumed items.

Table 4.11 Average absolute deviation from initial consumption levels for items in revised diets developed from SID-1 using quadratic objective functions (Eqns. 4.9, 4.12).

Initial Consumption (grams/week)	Average Absolute Deviation From SID-1		
	# of Items	Eqn. 4.9 (grams)	Eqn. 4.12 (grams)
0	124	61	61
>0-50			
51-100			
101-150			
151-200			
201-250			
251-300	1	280	280
301-350			
351-400			
401-450			
451-500			
501-550			
701-750			
1551-1600			
2751-2800			
3201-3250			
5651-5700	1	3681	3722
9351-9400	1	5968	5972

Table 4.12 Average absolute deviation from initial consumption levels for items in revised diets developed from SID-2 using quadratic objective functions (Eqns. 4.8-4.12).

Initial Consumption (grams/week)	# of Items	Average Absolute Deviation From SID-2 Eqn. 4.8 (grams)	Eqn. 4.10 (grams)	Eqn. 4.11 (grams)	Eqn. 4.9 (grams)	Eqn.4.12 (grams)
0	44	56	3	0.03	22	0.01
>0-50	22	43	102	104	32	11
51-100	22	82	129	136	77	59
101-150	8	74	109	116	81	95
151-200	14	129	248	256	191	260
201-250	1	28	72	85	34	59
251-300	4	102	209	222	261	526
301-350	3	167	212	218	190	226
351-400	2	131	260	263	303	380
501-450	1	37	44	57	338	567
451-500	1	378	489	495	495	495
501-550	1	70	191	208	59	256
701-751	1	100	286	311	732	732
1551-1600	1	28	84	92	1294	1600
2751-2800	1	29	89	95	2800	2800
3201-3250	1	11	123	144	1348	4638

Penalizing deviation of non-consumed items relative to consumed items has resulted in only minor changes in the solution profiles. With respect to the number of items contained in the diets developed from SID-1 (Table 4.7), both objectives (Eqns. 4.9, 4.12) have retained two of the three original items. The percentage objective weighting against non-consumed items (Eqn. 4.12) has added 74 new items; one greater than the other percentage objective (Eqn. 4.9). The greater penalty load on non-consumed items has altered the relative utility of one additional item to provide nutrients to meet the constraints. This item has subsequently entered the solution at 1 gram per week.

With respect to the number of items in diets developed from SID-2 (Table 4.8), some of the differences between the revised diets developed with the percentage formulation (Eqn. 4.9) and with the direct formulation (Eqn. 4.8), observed previously, have been amplified with the formulations (Eqn. 4.10-4.12) penalizing non-consumed item deviations. In particular, the number of consumed items retained in the direct formulation solutions have decreased further, from 53 without additional penalty on non-consumed items (Eqn. 4.9), to 50 and 47 with penalties of 100 (Eqn. 4.10) and 10,000 (Eqn. 4.11) on non-consumed items, respectively. The percentage formulation with additional penalties on non-consumed items (Eqn. 4.12) has increased the number of consumed items retained -- 66 as compared to 61 from the formulation with no additional penalty applied to zero items (Eqn. 4.9). Again, it is not clear that the outcome results from other than the circumstances associated with this one particular diet.

The number of initially non-consumed items in the revised diets developed with the direct formulation have increased from 17 with no penalty on non-consumed items (Eqn. 4.8) to 20 with penalties on non-consumed items (Eqns. 4.10, 4.11). Conversely, the revised diet developed with the percentage formulation which penalizes non-consumed item deviation (Eqn. 4.12) has 20 new items as compared to 21 from its counterpart without the additional penalty (Eqn. 4.9). Although all the above outcomes meet the objective of minimizing the summed deviation of items, the slight reduction in new items entering the solution developed with the percentage formulation is more consistent with the intent of penalizing the deviation of non-consumed items; that is, the penalty should reduce the number of new items entering the solution rather than increase them, as is the case with the revised diets from the formulation using direct squared deviation.

This discussion of phenomena associated with differently weighting the deviations of specific items has been restricted to a few examples where non-consumed versus consumed items have been differentially penalized. However, these observations should be applicable to other specific situations.

4.3.2.2.3 Penalty Coefficient, w_i, Further Comments

As discussed above, penalty coefficients can be used to influence the deviation of items from initial levels. How a particular penalty coefficient will affect the solution is a product of a number of factors, namely: the nutrient distribution in the items considered, the quantities of the items consumed in the initial diet, and the nutrient constraints applied. The complex interactions inherent in these factors underlines the real problem in trying to establish penalty coefficients which function to provide useful revisions for many different situations.

4.3.2.3 First Term: Further Modifications of the Algorithm

As presently formulated the objective function (Eqn. 4.1) does not control the direction or extent of change. It would appear realistic that the desirability of an increase or decrease in a particular item may be different, and hence that the penalty coefficient applied should reflect this difference. In this regard, a quadratic objective can be formulated to consider, separately, positive and negative deviations in item clusters. In more detail, this algorithm finds the combination of item clusters which minimizes the total, squared, weighted-positive and weighted-negative deviations in the amounts of each item cluster from initial consumption levels, while satisfying nutrient constraints. The linear form of this objective function has been given already (Eqn. 4.3). The formulation is as follows:

(4.13) $$\text{minimize} \sum_{i=1}^{I} (w_i^+ x_i^+ + w_i^- x_i^-)^2$$

(4.14) $$\text{subject to } x_i^+ - x_i^- = x_i - x_i^0 \qquad (i = 1, 2, \ldots, I)$$

(4.15) $$m_q \geq \sum_{i=1}^{I} a_{qi} x_i \geq n_q \qquad (q = 1, 2, \ldots, Q)$$

(4.16) $$r_{uv} \geq \frac{\sum_{i=1}^{I} a_{ui} x_i}{\sum_{i=1}^{I} a_{vi} x_i} \geq t_{uv} \qquad (u,v = \text{any specified set of nutrient pairs})$$

(4.17 $$x_i, x_i^+, x_i^- > 0 \qquad (i = 1, 2, \ldots, I)$$

where the terms are as previously defined (p. 142). Further elaboration of this algorithm could include separable programming to assign different penalty weighting to different portions of the curve.

To ensure that changes fall within specified limits, constraints could be appropriately included to provide minimum and maximum limits on the deviation in the amounts of specific item clusters. This expression is as follows:

$$d_i \geqslant (x_i - x_i^0) \geqslant e_i \qquad (4.18)$$

where the newly defined terms are:

d_i and e_i are, respectively, the upper and lower bound on the deviation in specific item clusters. If $d_i = 0$ then the revised consumption of the item cluster cannot be greater than the original consumption level. If $e_i = 0$ then the revised consumption of the item cluster cannot be less than the original consumption level.

The constraints used should be carefully applied so as not to interfere with solution feasibility.

The formulations just described (Eqns. 4.13-4.18) have not been tested, but provide the basis for desirable future work.

4.3.2.4 Second Term of the Objective Function

The first term of the objective function represents the acceptability of an item deviating from its initial dietary levels. In this first term the acceptability of this deviation is described as independent of specific concurrent changes in other items. Further, the first term does not consider changes in other dietary attributes, only in terms of the item clusters themselves.

Presumably, however, the acceptability of an item deviating from initial dietary levels depends not only upon the nature of the deviation of that food itself, but also upon the nature of concurrent deviations of the other foods in the consumption pattern, and of changes in other characteristics of the diet and in the diet as a whole. In any case, such an assumption would appear more realistic than the assumption that food preferences are not modified by changes in the consumption levels of the different foods.

Two basic types of compensatory relationships between foods have been described (Smith 1963), namely, incompatabilities and complementarities. Incompatible foods are those which clash or disagree, absolutely or in some proportion. They typically vary in inverse proportion. On the other hand, complementary foods either enhance one another, or their coexistence may be essential to palatability or acceptability. Complementary foods tend to vary in direct proportion. These relationships are applicable to item clusters and attribute groups.

The second term of the model's objective function contains the mathematical expression used to minimize the deviation of attribute groups from their initial levels, and to establish the relationships of concurrent change between item clusters and attribute groups. At present, only incompatibility between item clusters and attribute classes has been considered in establishing the relationships of concurrent change. This term minimizes the summed weighted square of differences between the amounts of item cluster groups -- called attribute groups -- in the initial and recommended diets, as follows:

$$(4.19) \qquad \text{minimize} \sum_{k=1}^{K} \sum_{j=1}^{J_k} P_{jk} \left(\sum_{i \in G_{jk}} (x_i - x_i^0) \right)^2$$

The complete formulation incorporating this additional term given in Equations 3.2 to 3.5.

The addition of this second term is expected to modify the output profiles as compared to those produced without it. First, if the deviations of attribute groups are increasingly penalized, then the quantity of these attribute groups in the revised diet should approach initial levels. Thus, this term allows for monitoring general food and diet characteristics considered important to the diet's acceptability. Second, if emphasis on maintaining initial levels of attribute groups increases, the attribute structure encourages the item clusters within each attribute group to vary in inverse proportion.

Thus, the second term tends to cause substitution between the presumed nearest acceptable alternative for an item cluster or attribute group. This relationship of concurrent change between item clusters and attribute groups is, in a sense, an artifact of assigning those elements with like characteristics into the hierarchy of successive subgroups, groups, and supergroups, outlined in Appendix G.

The number of item clusters contained in any attribute group and the number of attribute groups to which any item is assigned will influence whether substitution between items will be apparent. Where only two items are contained in a group, the shift between these grouped partners should be more apparent than when a large number of items is contained in a group. Where an item cluster has simultaneous membership in many attribute groups, as is the case above, (Eqn. 4.19), the exact outcome is dependent on the relative emphasis on the deviation of each attribute group considered.

It should be noted that the dynamics between the attribute groups on each hierarchical level, k=1 to k=7, should be similar to those previously discussed for item clusters in the zeroth hierarchical level.

4.3.2.5 Second Term: Shape of the Curve

The second term, as expressed in Equation 4.19, also describes a quadratic curve centered at the initial consumption level of each attribute group defined, as shown in Figure 4.3. Thus the relative unacceptability of differences between the initial and revised values for any attribute element is strongly intensified by this quadratic objective.

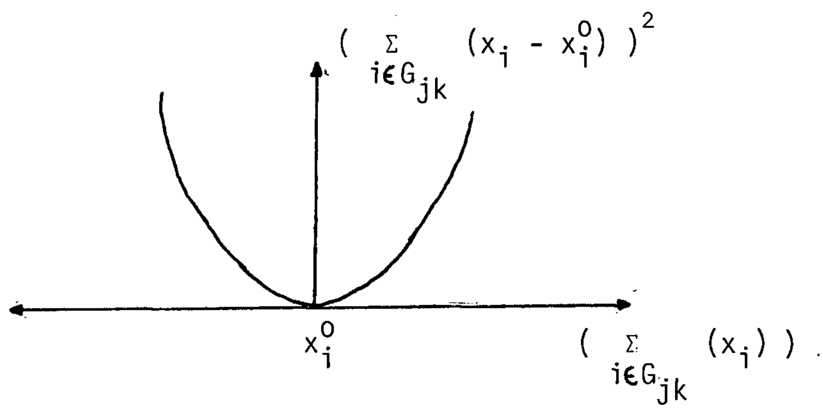

Figure 4.3 Graph of quadratic function for deviation from initial consumption of attribute group G_{jk}.

Other non-linear or linear functions may be appropriately used to describe the acceptability of these attribute elements deviating from initial levels, and to describe the interactional properties of individual items and of attribute groups. The second term of the objective function (Eqn. 4.19) can be readily transformed to the linear equivalent. This minimizes the total, weighted-positive and weighted-negative deviation in the amount of specified groups from initial consumption levels. With the addition of this linear second term the linear formulation (Eqns. 4.3-4.7) becomes:

$$(4.20) \quad \text{minimize} \sum_{i=1}^{I} (w_i^+ x_i^+ + x_i^- w_i^-) + \sum_{k=1}^{K} \sum_{j=1}^{J_k} (p_{jk}^+ z_{jk}^+ + p_{jk}^- + z_{jk}^-)$$

(4.21) subject to $z_{jk}^{+} - z_{jk}^{-} = \sum_{i \in G_{jk}} (x_i^{+} - x_i^{-})$ $(j = 1, 2, \ldots, J_k)$
$(k = 1, 2, \ldots, K)$

(4.22) $x_i^{+} - x_i^{-} = x_i - x_i^{0}$ $(i = 1, 2, \ldots, I)$

(4.23) $m_q \geqslant \sum_{i=1}^{I} a_{qi}\, x_i \geqslant n_q$ $(q = 1, 2, \ldots, Q)$

(4.24) $r_{uv} \geqslant \dfrac{\sum_{i=1}^{I} a_{ui}\, x_i}{\sum_{i=1}^{I} a_{vi}\, x_i} \geqslant t_{uv}$ (u,v = any specified set of nutrient pairs)

(4.25) $x_i,\ x_i^{+},\ x_i^{-},\ z_{jk}^{+},\ z_{jk}^{-} \geqslant 0$

Where the newly defined terms are as follows:

z_{jk}^{+}, z_{jk}^{-} are the positive and negative deviation, respectively, of attribute group j in the k^{th} hierarchical level.

$$z_{jk}^{+} = \begin{cases} \sum_{i \in G_{jk}} (x_{jk}^{+} - x_{jk}^{-}) & \text{if } \sum_{i \in G_{jk}} (x_i^{+} - x_i^{-}) > 0 \\ 0 & \text{otherwise} \end{cases}$$

$$z_{jk}^{-} = \begin{cases} -\sum_{i \in G_{jk}} (x_{jk}^{+} - x_{jk}^{-}) & \text{if } \sum_{i \in G_{jk}} (x_i^{+} - x_i^{-}) < 0 \\ 0 & \text{otherwise} \end{cases}$$

p_{jk}^{+}, p_{jk}^{-} are the weighted penalty associated with the positive or negative deviation, respectively, of attribute group j in the k^{th} hierarchical level.

Since the linear and quadratic formulations of the objective functions first term are expected to generate different solutions, we can correspondingly expect changes with these formulations incorporating both the first and second terms. The quadratic objective would be expected to moderate extreme fluctuations in any particular item cluster or attribute group in favour of numerous smaller changes. The linear model, however, should be insensitive to large deviations in specific items, provided these changes are consistent with the overall objective of reducing aggregate deviation of item clusters and attribute groups. For example, if all foods provided the same nutrient contributions, the quadratic objective (Eqn. 3.2) would spread deviations over all items and attribute groups in exact proportion to the penalty coefficients applied. The linear objective (Eqn. 4.20) would be insensitive to how the total deviation was apportioned over item clusters and attribute groups. These expectations are not illustrated here since the linear solutions were not developed for comparison with the quadratic results.

4.3.2.6 Second Term: Penalty Coefficients, w_i and P_{jk}

The impact on the solution of altering the relative weighting of the penalty coefficients, w_i and P_{jk}, should also be considered. By altering these penalty coefficients, the value of increments for an item cluster or attribute group can be exaggerated or depressed, and with it the emphasis on concurrent change of items. As previously discussed, the numerical value of the penalty coefficients can be based on various rationales for perceived acceptability of change. The coefficient chosen can represent: differences in initial consumption levels for each item or group; whether an item or group is initially consumed or not consumed; differences in standard serving sizes; the average consumption levels observed in a population; or some other measure of personal preference. In this instance, all penalty coefficients were arbitrarily assigned as "1" for deviation of any item cluster, and "1" or "0" for deviation of attribute groups depending on whether the deviation of a particular group was to be considered in the computation.

In order to observe the impact of including the second term of the objective function (Eqn. 4.19), three different objective functions (Eqns. 4.26-4.28) were defined. Each of these objective functions minimizes the summed, squared deviation of both item clusters and specified attribute groups from initial levels. A numerical value of 1 has been assigned for weighting penalty coefficients, w_i and P_{jk}. The first objective function (Eqn. 4.26) sums the deviations of all item clusters and of attribute groups on the first hierarchical level, whereas the second objective function (Eqn. 4.27) sums the deviations of all item clusters and of attribute groups on both the first and second hierarchical levels. The third objective function (Eqn. 4.28) sums the deviations over all item clusters and attribute groups on levels, k=1 to k=7, and the total diet's amount, k=8. The algebraic expressions corresponding to these objective functions are as follows:

$$\text{(4.26)} \quad \text{minimize} \sum_{i=1}^{I} 1(x_i - x_i^0)^2 + \sum_{k=1}^{1} \sum_{j=1}^{J_1} 1\Big(\sum_{i \in G_{jk}} (x_i - x_i^0) \Big)^2$$

$$\text{(4.27)} \quad \text{minimize} \sum_{i=1}^{I} 1(x_i - x_i^0)^2 + \sum_{k=1}^{2} \sum_{j=1}^{J_2} 1\Big(\sum_{i \in G_{jk}} (x_i - x_i^0) \Big)^2$$

$$\text{(4.28)} \quad \text{minimize} \sum_{i=1}^{I} 1(x_i - x_i^0)^2 + \sum_{k=1}^{8} \sum_{j=1}^{J_8} 1\Big(\sum_{i \in G_{jk}} (x_i - x_i^0) \Big)^2$$

Using these objectives (Eqns. 4.26-4.28) revised diets were developed from Standard Initial Diet 2, and compared with the solution obtained from an objective function (Eqn. 4.8) previously described, which minimizes only the summed, squared deviation of item clusters from initial quantities (Table 4.13). Table 4.14 gives nutrient composition of the initial and revised diets for each of these objective functions (Eqns. 4.26-4.28).

Table 4.13 Revised diets developed from SID-2 using quadratic objective functions (Eqns. 4.8, 4.26-4.28).

GROUP-ITEM CODE #	FOOD ITEM	SID-2 (grams/week)* Initial	Eqn.4.8	Eqn.4.26	Eqn.4.27	Eqn.4.28
	ENTREE-DAIRY					
001-003	CHEDDER CHEESE.	182	519	538	508	499
001-004	COTTAGE CHEESE.					
001-005	CREAM CHEESE...					
002-006	SOUR CREAM.....					
002-008	YOGHURT........					
003-010	EGG............	495	117	96	7	
	ENTREE CEREALS					
004-012	CORN CEREAL...	23	210	196	167	401
004-013	WHEAT CEREAL..		221	87	112	17
005-015	OATMEAL.......	270	187	115	35	
005-016	WHEAT CEREAL..		24	96	103	
006-017	PANCAKES......	135				
007-018	NOODLES.......					
007-019	SPAGHETTI.....					
008-020	RICE, brown...		75	69	81	15
008-021	RICE, white...		39	9		
008-023	WHEAT GERM....					
009-024	FRENCH BREAD..	40	63			
009-027	WHITE BREAD...	414	451	409	263	104
009-028	WHOLE WHEAT BREAD.........		138	198	278	327
010-031	BUSCUITS......	70				
010-032	HAMBURGER BUN.	46	83	64		
010-033	MUFFIN........	40				
010-035	ENGLISH MUFFIN	46	184	267	306	276
011-037	SALTINES......	24	6			
011-040	RYE KRISP.....		221	183	176	133
	ENTREE-MEATS					
012-041	BEEF, 30% fat.	170		74	67	
012-042	BEEF, 20% fat.	85				
012-043	BEEF, 15% fat.	170				
012-046	PORK, lean cut	85				
012-047	PORK, all hams	43			100	145
012-048	BACON.........	64				
013-049	CHICKEN, steamed					
013-051	CHICKEN, fried.	340		5		
014-055	FRIED FISH....					
014-056	BROILED FISH..					

* Values rounded to the nearest grams/week.

Table 4.13 (Continued)

014-058	OYSTERS........					267
014-062	SARDINES.......					
014-063	SHRIMP.........	43				
014-065	TUNA..........	60	22	69	127	102
015-067	LIVER..........					
017-069	FRANKFURTERS...					
017-070	FRESH SAUSAGES.	40				
017-071	LIVERWURST.....		98	84	36	99
018-073	BEANS, dried...					83
018-075	SOYBEANS.......					
019-076	ALMONDS........					
019-077	CASHEW NUTS....	15				
019-079	PEANUT BUTTER..	28				
019-080	PEANUTS........	120	10	16		
019-081	PECANS.........		85	147	155	184
	ENTREE-VEGETABLES					
020-082	POTATOE, baked.	100				
020-083	POTATOE, fried.	100				
020-084	POTATOE, mashed	200	82	88		
020-085	SWEET POTATOE..	180	218	446	411	393
021-089	BEANS, green...	65	253			
021-091	BROCOLLI.......	63	363	330	385	481
021-092	CABBAGE........	65	180			
021-095	LETTUCE........	180	178	23	34	90
021-098	PEAS...........	170	572	525	471	427
021-099	PEPPERS........		374	316	329	388
021-101	SPINACH........	85	182	3		
022-103	BEETS..........	80	158	193	165	150
022-104	CARROTS, cooked	76	146	172	160	168
022-105	CARROTS, raw...	50	70	112	162	194
022-106	CORN...........		109	70		
022-111	TOMATOE........	518	448	341	216	
023-113	CUCUMBER.......	275	210	137		
023-115	ONIONS.........	8	119	238	201	97
024-116	SUCCOTASH......		149	215	127	50
025-117	OLIVES.........		380	475	475	507
025-118	PICKLES, sweet.	20				
025-119	PICKLES, sour..	34				
	ENTREE-FATS					
026-121	LARD...........	5				
026-124	SOYBEAN OIL....					
027-125	BUTTER.........	125	22			
028-127	CHEESE SAUCE...			21	51	
028-128	GRAVY..........	72				

Table 4.13 (Continued)

029-132	MAYONNAISE........	105	21			
029-133	SALAD DRESSING....	90	70	79	76	42
	BEVERAGES-DAIRY					
030-136	WHOLE MILK........	732	632	652	702	711
030-137	SKIM MILK.........					2
031-140	TABLE CREAM.......	195	93	81	150	191
031-141	WHIPPED CREAM.....	8				
	BEVERAGES-FRUIT					
032-143	APPLE JUICE.......			86	151	267
032-144	GRAPEFRUIT JUICE..	120				
032-145	LEMON JUICE.......	5			10	
032-148	ORANGE JUICE......	360	174	219	212	158
033-150	TOMATOE JUICE.....				34	53
	BEVERAGES-MISC.					
034-151	COLA-TYPE.........	339	328	323	328	352
035-153	COFFEE............	2800	2771	2788	2799	2814
035-154	TEA...............	1600	1572	1581	1581	1581
036-155	BEER..............	3240	3229	3251	3264	3304
036-156	DISTILLED SPIRITS.	43	34	68	72	71
036-158	DRY WINES.........	400	324	321	324	302
	SOUPS					
037-160	CREAMED SOUPS.....	198	145	184	233	248
037-161	PEA SOUPS.........	200	99	59		
037-163	MEAT + VEGIE SOUPS			74	106	121
	DESSERTS-CEREALS					
038-166	COFFEE CAKE.......	75				
038-168	FRUITCAKE.........					
038-170	ICED CAKES........	60				
039-171	FRUIT PIES........	160	219	248	306	237
039-172	PUMPKIN PIES......	150	123	86	88	
040-173	COOKIES...........	60				
040-174	FRUIT COOKIES.....		400	496	554	585
041-175	CAKE DOUGHNUTS....	60				
041-177	DANISH PASTRY.....	38				
	DESSERTS-DAIRY					
042-178	ICE-CREAM.........	270	185	135	145	6
042-179	SHERBERT..........		15	85	102	218
043-181	PUDDINGS..........	185	107	116	147	104
	DESSERTS-FRUIT					
044-183	APPLE.............	300	485	608	661	741
044-184	APPLESAUCE........	185	284	288	225	165

Table 4.13 (Continued)

044-185	BANANA..............	100	44	40	83	
044-186	CANTALOUPE........	100				
044-187	GRAPEFRUIT........	200	135			
044-188	ORANGE............	150	159	217	242	189
044-192	PINEAPPLE.........		37	18		
045-193	DRIED FRUIT.......					
	DESSERTS-SWEETS					
047-195	HONEY.............		33	19	51	123
047-197	SUGAR.............	105	109	125	110	25
048-198	JAMS..............	100	99	49	18	23
048-199	SYRUP.............	40	129	172	223	179
049-201	CHOCOLATE CANDY...					
049-202	MARSHMALLOW.......		44	30	38	106
	MISCELLANEOUS					
051-205	POT PIES..........	227	199	195	155	168
063-217	SPAGHETTI + MEAT..	330	179	208	213	240
067-221	COCOA MIX.........	7				
	Total Grams/Week..	18889	19461	19288	19117	18933
	Total # of Items..	83	70	68	61	55
	# of Initial Items	83	53	48	43	36
	# of New Items....		17	20	18	19
	# of Items Dropped		13	15	22	28

Table 4.14 Nutrient composition of the SID-2, and the revised diets developed using quadratic objective functions (Eqns. 4.26-4.28).

Nutrient	Nutrient Minimum (/week)	Constraints Maximum (/week)	SID-2 Initial (/week)	SID-2 Eqn.4.26 (/week)	SID-2 Eqn.4.27 (/week)	SID-2 Eqn.4.28 (/week)
PROTEIN(gm)	392.00	558.60	713.82	558.60	558.60	558.60
CHO-T (gm)	2735.4	4476.1	1872.4	2735.4	2735.4	2735.4
T-FAT(gm)	44.209	663.13	981.39	658.14	663113	663.13
KCAL	18899.	20889.	20195.	19810.	19832.	19881.
CHO-F(gm)	79.576	159.15	32.250	79.576	79.576	79.576
SFA(gm)	.0	221.04	367.46	221.04	221.04	210.90
SUCR(gm)	.0	746.02	549.60	746.02	746.02	738.58
PUFA(gm)	44.209	663.13	543.42	364.07	360.24	362.29
VIT-A(iu)	35000.	.140E+06	69952.	0.107E+06	95816.	94650.
VIT-E(mg)	63.000	700.00	75.273	90.631	91.075	94.316
VIT-C(mg)	210.00	3500.0	886.80	1231.6	1248.2	1375.4
THIA(mg)	9.9470	19.894	10.292	11.496	11.190	11.448
RIBO(mg)	11.936	23.873	13.803	13.038	12.289	13.194
NIAC(mg)	131.30	262.60	178.25	131.30	131.30	131.30
VIT-B6(ug)	14000.	28000.	12942.	14000.	14000.	14000.
FOLATE(mg)	1400.0	2800.0	1460.9	1400.0	1400.0	1400.0
POTAS(mg)	9800.0	19600.	22490.	19600.	19600.	19600.
CAL(mg)	5600.0	11200.	6137.3	8960.0	8960.0	8960.0
PHOSP(mg)	5600.0	11200.	11258.	11200.	11200.	11200.
IRON(mg)	70.000	140.00	120.08	135.86	130.87	140.00
MAG(mg)	2205.0	4410.0	2386.5	2751.3	2717.7	2562.4
CA/P	.8	1.2	0.54514	0.80000	0.80000	0.80000
P/S	1.0	2.0	1.4789	1.6471	1.6297	1.717

As noted, the second term in the objective function is expected to reduce the deviation of attribute groups from their initial levels. This deviation should be roughly proportional to the penalty coefficient applied -- in this instance 1 or 0. In order to illustrate this phenomenon, the average absolute deviations of item clusters and of attribute groups in each hierarchical level have been determined for the revised diets of Table 4.13 and compared in Table 4.15. As expected, where the deviation of an attribute group is penalized -- $P_{jk} = 1$ -- average absolute deviation is consistently lower relative to the condition where the deviation of that levels groups is not penalized -- $P_{jk} = 0$. For example, the average absolute deviation of groups in each hierarchical level, k=3 to k=8, is lower when the deviations of attribute groups are penalized by the objective function (Eqn. 4.28) as compared with the case when the deviations are not penalized (Eqns. 4.8, 4.26, 4.27). Where the objective functions have equally penalized the deviations of groups on any particular level, the outcome is roughly dependent on the amount of emphasis on other group deviations. Thus, as emphasis shifts towards attribute groups in higher numbered hierarchical levels, there is a coincident alteration in deviation of item clusters and attribute groups at lower hierchical levels.

Table 4.15 Average absolute deviation of item clusters and of attribute groups in each hierarchical level from initial levels, and the penalty coefficients assigned for each hierarchical level.

Hierarchical Levels	# of Items of Groups/ Level	Average Absolute Deviation From SID-2* and values of w_i and P_{jk}.							
		Eqn.4.18		Eqn.4.26		Eqn.4.27		Eqn.4.28	
		(gm)	(w_i/P_{jk})	(gm)	(w_i/P_{jk})	(gm)	(w_i/P_{jk})	(gm)	(w_i/P_{jk})
	127	75	1	86	1	95	1	106	1
k=1	50	167	0	136	1	130	1	149	1
k=2	39	190	0	163	0	136	1	124	1
k=3	34	207	0	176	0	149	0	132	1
k=4	23	297	0	252	0	214	0	176	1
k=5	20	308	0	253	0	210	0	155	1
k=6	12	490	0	402	0	340	0	235	1
k=7	4	763	0	571	0	394	0	244	1
k=8	1	572	0	399	0	288	0	44	1

* values rounded to nearest gram.

The different treatment of deviation by these objective functions (Eqns. 4.26 - 4.28) shows in the character of the solution profiles. With respect to the number of items contained in the SID-2 revised diets, as more attribute groups are considered, the total number of items in the revised diet and the number of items included from the initial diet has consistently decreased (foot of Table 4.13). Although this phenomenon need not occur in every instance, it is not an unreasonable outcome. In order to meet nutrient constraints the objective seeks to change the limited set of most efficient nutrient sources. As indicated previously, the quadratic penalty function restricts the extent to which any particular item can act as an efficient nutrient source. Consequently, the limited set changed may correspond to a larger number of items than would be predicted from comparing the nutrient concentration of items alone. As the deviation in attribute groups in penalized, the deviation of item clusters which act as efficient nutrient sources is amplified. The result is in this instance, that as emphasis on attribute group deviation has increased, progressively more initially-consumed items have declined to zero and thus dropped from the revised diets; that is, thirteen initially-consumed items have deviated to zero when no penalty was applied on attribute group deviations (Eqn. 4.8), whereas 15, 22, and 28 items have deviated to zero as the penalty was increased (Eqns. 4.26-4.28). In these revised diets the number of new items which have entered the solution varies only slightly, between 17 and 20.

Another outcome, of particular interest, is the impact of the attribute structure on concurrent deviation of item clusters. That is, does the attribute structure influence compatibility relationships between item clusters by causing these items to vary in inverse proportions, or to substitute? It is apparent from previous results that when attribute group deviations are penalized, item clusters within these attribute groups tend to substitute. That this occurs is, ipso facto, a condition of changes in the item profile of the revised diet and the simultaneous reduction in the attribute group deviation in these revised diets.

It is obvious that these shifts have not occured item for item, since there has been a general reduction from the initial condition in the total number of items in the revised diet. However, if the revised diet from the objective function (Eqn. 4.8), which does not penalize deviation of attribute groups, is compared with the objective function (Eqn. 4.26) that penalizes deviation of all attribute groups on hierarchical level "1", one slight substitution effect can be illustrated (Table 4.16); that is, 41 attribute groups represented in SID-2 hierarchical level "1" are more often represented, 38 to 35, in the revised diet when those attribute groups are penalized (Eqn. 4.26) as opposed to when the attribute groups are not penalized (Eqn. 4.8).

Table 4.16 Effect of penalty assignment on the number of attribute groups containing consumed item clusters.

Hierarchy Levels	# of Groups/ Level	# of Groups/Level Containing Consumed Item Clusters		
		SID-2 Initial	SID-1 Eqn. 4.8	SID-2 Eqn. 4.26
k=1	50	41	35	38

Although the addition of the second term to the objective function has altered the solution in expected ways, the specific details of these changes are not easily monitored. If such an approach for modelling concurrent changes between items is realistic, its success depends on appropriately weighting the relative acceptability of each attribute group's deviation from initial levels.

4.3.2.7 Second Term: Further Modifications of the Algorithm

Apart from affecting the solutions by altering the penalty weighting for attribute group deviation, it may be useful to consider: selectively penalizing positive and negative deviation of attribute groups; and transforming the objective's second term into a constraint which restricts attribute group deviation.

(i) As presently formulated, the objective function's second term (Eqn. 4.19) does not provide an opportunity to specify different penalties for positive, as opposed to negative, deviation of attribute groups. A quadratic second term can be formulated which minimizes the total, weighted-positive and weighted-negative deviation in the amounts of attribute groups from initial consumption levels, as follows:

(4.29) $$\text{minimize} \sum_{k=1}^{K} \sum_{j=1}^{J_k} (p_{jk}^{+} z_{jk}^{+} + p_{jk}^{-} z_{jk}^{-})^2$$

(4.30) $$\text{subject to } z_{jk}^{+} - z_{jk}^{-} = \sum_{i \in G_{jk}} (x_i - x_i^o) \quad (j = 1, 2, \ldots, J_k) \quad (k = 1, 2, \ldots, K)$$

(4.31) $$z_{jk}^{+}, z_{jk}^{-} \geq 0$$

Where the terms are as previously defined (p. 181).

(ii) To ensure that changes in attribute groups fall within specified limits, a constraint can be appropriately included in the algorithm (Eqns. 3.2-3.5), or substituted for the second term of the objective function (Eqn. 4.19). This constraint provides upper and lower bounds on the deviation in the amounts of attribute groups, as follows:

(4.32) $$b_{jk} \geq \sum_{i \in G_{jk}} (x_i - x_i^o) \geq c_{jk} \quad (j = 1, 2, \ldots, J_k) \quad (k = 1, 2, \ldots, K)$$

Where the newly-defined terms are:

b_{jk} and c_{jk} are respectively, the upper and lower bounds on the deviation of attribute group j in the k^{th} hierarchy level. If b_{jk} = 0 then the revised consumption of the attribute group j cannot be more than the original consumption of group j. If c_{jk} = 0 then the revised consumption of attribute group j cannot be less than the original consumption of group j.

(iii) The second term of the objective function (Eqn. 4.19) only considers compatibility relationships among item clusters. Complimentarity between items has been largely neglected in the algorithm's design, with the exception of choosing items with low complementary characteristics where possible. For example, bread has been chosen for the food item list rather than its ingredients -- flour, water, yeast. Therefore, it may be worthwhile to add a term to the objective function (Eqn. 3.2) which considers complementary relationships by minimizing the total, weighted squared deviation in the ratio of the amounts of specified item clusters from initial consumption levels. The formulation is:

$$\text{(4.33)} \qquad \text{minimize} \sum_{(h,l) \in s_{hl}} f_{hl} \left(\frac{x_n}{x_l} - \frac{x_h^o}{x_l^o} \right)^2 \qquad \text{(h,l = any specified pair of item clusters)}$$

Where the newly-defined terms are:

x_h^o, x_l^o are the amounts, in grams, of specified item clusters h and l, respectively, contained in the client's initial diet.

x_h, x_l are the amounts, in grams, of specified item clusters h and l, respectively, contained in the revised diet.

s_{hl} is the set of item cluster pairs (h,l) for which the deviation from the initial ratio $\frac{x_h^o}{x_l^o}$ is being penalized.

f_{hl} is the penalty associated with the deviation of item cluster pairs (h,l) from the initial ratio $\frac{x_h^o}{x_l^o}$.

(iv) The above term (Eqn. 4.33) can be transformed to a constraint which restricts the deviation in the ratios of specific item clusters. The expression is:

$$\text{(4.34)} \qquad \partial_{hl} \geqslant \frac{x_h}{x_l} - \frac{x_h^o}{x_l^o} \geqslant \Psi_{hl} \qquad \text{(h,l = any specified pair of item clusters)}$$

Where the newly-defined terms are as follows:

∂_{hl} and Ψ_{hl} are respectively, the upper and lower bounds on how much the ratio of item clusters h and l will be allowed to change from the initial ratio $\frac{x_h^o}{x_l^o}$.

4.4 Summary and Comments on Testing the Algorithm

As indicated (p. 128), testing the diet planning phase has been limited to a descriptive evaluation of some of the algorithm's characteristics -- specifically, the premises and assumptions which define the acceptability of altering a diet, and the revised diets developed when these assumptions are modified. To reiterate, these assumptions include:

(i) A concept of attributes which form the basic practical and conceptual entities that the individual is conditioned to respond to and uses to identify a diet's character. These attributes are used to categorize foods into a matrix of attribute groups -- an attribute map.

(ii) The acceptability or perceived extent of change is considered dependent on the significance of maintaining each element of the map at its initial amount with respect to itself and to other elements, and on how this significance is altered when the relative or absolute proportions of the map elements change.

Within the context of the premises established for the algorithm's design (p. 136), modifications in the assumptions about acceptability of dietary change can be proposed, and incorporated in the design of the model's objective function or constraints. Here, only some features of the objective function were explicitly modified -- specifically, the attribute elements defined and the penalty coefficients for deviation of these defined-items. The results illustrate that altering these features produces marked variations in the revised diets with respect to the observed parameters -- that is, deviations in the amounts of items and changes in the number of items. It is expected that the other modifications in the algorithm's objective function and constraints, described above, should also have an impact on the revised diets developed.

The descriptive evaluation was undertaken to explore the conceptual and technical feasibility of using this type of mathematical model for approximating an individual's nutrient-constrained food choice, given his or her diet inventory. Thus, the evaluation provides insight into the ability of the model to adapt to a variety of output demands.

Although this explorative evaluation was not intended to verify the diet-planning model's operation, the implicit question throughout is which, if any, of these approaches provides the closest approximation to the nutrient-allowed food choice an individual would make given that the individual could understand, accept, and utilize nutrient information. It would seem unlikely that all variations of the revised diets developed from a given dietary inventory using different objectives would be equivalent in acceptability to the client. However, any judgement about the most appropriate formulation must be purely subjective at present. Hence, manipulation of the algorithm and observation of the solution's sensitivity to these modifications, do not immediately provide information on the perceived acceptability of the dietary revision.

It may appear that the most appropriate model can be easily determined by selecting the most limiting solution -- that is, the one that deviates least from the original diet. However, as the results demonstrate, this is not a mathematical concept which can be objectively appraised without choosing one of the many possible definitions of "minimum deviation". Given any such definition the algorithm provides a mathematically=optimal solution. Therefore, evaluations to determine which algorithm provides the least-changed solution, can only serve to corroborate or refute whether the algorithm and test procedure use the same optimality criterion.

In order to determine the validity of any particular algorithm for approximating the client's nutrient-constrained food choice, an empirical basis is required. The mathematically-optimal deviation of the revised diet from the initial diet must be equated to a behavioral or perceived optimum; or at least an explicitly-stated tradition or professional guideline on which to justify revisions. In this instance, as indicated in page 136 no appropriate tradition or guidelines exists for model development or testing. Appropriate empirical methods for evaluating the efficacy of the diet-planning model would include, first, comparison of the system output with client-generated or nutritionist-generated solutions, including observation of the client's behavioral response. Second, a less rigorous evaluation of the algorithm can be undertaken by considering the response of a client -- or a nutritionist acting as the client's agent -- to the system outputs.

Such definitive evaluation was judged premature, pending further explorative evaluation and system development, because of two major difficulties. First, establishing a test situation where the client or nutritionist could effectively use the same nutritional objectives as the computational method was not presently possible, even if the nutritional objectives could be agreed upon. This equivalent ability is important in order that solutions generated from different sources be comparable; or so that comments by client's and nutritionist's on computationally-produced diets be tempered with recognition of available nutrient-restricted options. Computer-assisted diet planning has been specifically employed in this project to ensure data handling capabilities unavailable to either clients or nutritionists without these means.

Second, even if the difficulty of providing a framework for comparison of computational and human methods can be overcome, the computationallygenerated solutions would be difficult to appraise constructively, either by comparison with human-generated solutions or by consideration of the responses of client's or nutritionist's. Although such evaluation could confirm or deny the acceptability of solutions, the relative acceptability of different computational solutions cannot be determined, except for exact or near-exact solution replicates, or certain acceptance of computational recommendations.

While difficulties are as relevant now as they were previously, the inquiry and observation undertaken have provided a basis on which to explore more usefully the validity of the algorithm's assumptions. The observations illustrate that the algorithm can be modified to accommodate a variety of different solution requirements. Although iterating the options available may be a lengthy process, these options can be systematically evaluated to establish which, if any, of the algorithms approaches the nutrient-constrained food choices of individuals. Also, such testing may provide for further understanding of the factors which influence the mathematical formulation in producing a solution judged to be useful. Perhaps of more importance, it may provide an opportunity to explore measurably the trade-offs between the nutritional goals of presenting accurate nutrient information, and the educational objectives of presenting simple, straightforward information.

CHAPTER 5

SUMMARY, RECOMMENDATIONS, AND CONCLUSIONS

5.1 Summary

5.1.1 The Thesis Goal

The overall thesis goal was to develop a system to provide information on dietary practices for adults who are motivated to apply nutritional principles to their eating habits, and who have sufficient resources to make use of the information required to define healthful dietary practices for them. This development was undertaken bearing in mind two primary problems, namely: the developing of nutritional guidelines suitable for health promotion, and the communication of these guidelines to individuals.

5.1.2 First Objective of the Thesis

The prototypical computerized system developed has two major functions: first, to assess the dietary intake of individuals (diet-assessment), and second, to recommend changes in food intake for those individuals with nutrient intake which do not meet specified limits (diet-planning).

5.1.2.1 Diet-Assessment Function

Standard dietary assessment procedures of data collection, analysis, and evaluation, were adopted for the system's design. In the data collection phase, the initial diet of an individual is estimated by using an intake questionnaire. This information is then translated into nutrient data, in the data analysis phase, and evaluated in the evaluation phase by comparing calculated nutrient-intake with nutrient limits which represent an "acceptable" range of intake for the individual. The list of food consumed, and the results of data analysis and evaluation are displayed in the computer output.

The nutritional guidelines used for evaluating diets are largely based on the dietary standards of various countries and international agencies, and on dietary goals proposed by recognized scientific agencies. These guidelines are adopted for the system's design because they provide a technically accurate rationale for healthful food selection practice. However, it is recognized that this complex information on nutrients cannot easily be used to recommend dietary practices for individuals, and therefore would require translation into a statement of food and meals.

5.1.2.2 Diet-Planning Function

A revised diet is developed by a constrained-optimization model which determines the combination of foods, subject to nutrient constraints, that minimizes the total squared deviation of food items and item groups from their original amounts as specified on the client questionnaire. The revised diet is provided on the computer output.

This model has been developed to provide a recommended diet for motivated individuals which:

(i) accurately reflects nutritional guidelines, and

(ii) facilitates adoption of recommendations by providing a self-explanatory statement of foods to consume and by limiting the changes from present or desired food patterns.

Presumably, this would be similar to the diet which the individual would choose if she or he understood, accepted, and used nutritional knowledge

-- that is, the individual's nutrient-constrained food choice. The use of mathematical modelling provides an effective means of collating the vast amount of data required to develop dietary recommendations which are both nutritionally accurate, straightforward, and hopefully, acceptable to the client.

5.1.3 Second Objective of the Thesis

Following formulation of the diet-planning algorithm, the major task was to test this algorithm in order to explore the conceptual details of this diet-planning approach. Testing was restricted to a descriptive evaluation of some of the algorithm's characteristics -- specifically, the assumptions which define the acceptability of altering a diet and the revised diets developed when these assumptions are modified.

The assumptions defined included: first, a concept of attribute elements which form the basic practical and conceptual entities that the individual is conditioned to respond to and uses to identify a diet's character; second, the acceptability or perceived extent of change is considered to be dependent on both the significance of maintaining each element at its original amount with respect to itself and to other elements, and on the extent to which this significance is altered when the relative or absolute proportions of the map elements change.

A variety of modifications in the assumptions about acceptability of dietary change can be incorporated in the algorithm's design. In this instance, only certain features of the objective function -- specifically, the attribute elements defined and the penalty coefficients weighting deviation of these attribute elements -- were explicitly modified. The results illustrate that altering these features produced marked variations in the revised diets with respect to the observed parameters, that is, deviation in the amounts of items and changes in the number of items. Other modifications in the algorithm's objective function and constraints would also be expected to have an impact on the revised diets developed.

Although the explorative evaluation was not intended to validate whether the diet planning model can provide acceptable revisions of diets for clients, it does provide a foundation for more systematic evaluation of the validity of different approaches. As noted the algorithm can be modified to accommodate a variety of different solution requirements. These options can by systematically tested, by considering client or nutritionist-generated solutions or their responses, to establish which, if any, of the possible algorithms approximate the nutrient-constrained food choice of individuals.

5.2 Recommendations

Since iterating the available approaches may be a lengthy process, some recommendations which may facilitate exploration and development of a "commercially" viable model are now given.

5.2.1 First Recommendation

Emphasis should be given to reducing the absolute number of changes in revised diets rather than just minimizing deviation of item amounts. It became apparent while analyzing the results, that even though the revised diets deviate minimally and in fact could represent the real adjustments that individuals would make, these revisions were difficult to appreciate because so many changes had occured. In a nutrition education setting, realistic solutions may need to maintain many items at initial levels.

Some alterations in the algorithm that may reduce changes in the revised diet to a manageable level include:

(i) The use of a linear rather than a quadratic formulation. Although the quadratic penalty function may seem more realistic than the linear function, the quadratic function tends to spread deviation over all items. A linear function may provide fewer changes and thereby a more easily understood solution.

(ii) A formulation which restricts the items in the solution set to the originally consumed items and to a limited number of alternatives for guaranteeing solution feasibility may simplify outcomes; as might one which concentrates changes to specified types of items, such as low nutrient foods. Although the total deviation of item quantities may be greater using these means, the alterations may be easier for the client to monitor and appreciate.

(iii) Constraints on the deviation of items could be included to control the solutions, and would be particularly useful for a linear format. Some items may usefully be retained at initial levels.

(iv) In place of an integer formulation which would be difficult to develop, a routine to average item quantities in the revised diets to their nearest serving or half-serving should be considered. The loss of accuracy may be considerably offset by the increase in utility from removing inordinately small increments and decrements, and from simplifying the serving sizes reported.

(v) Solutions based on a more abbreviated set of item classes or food groups may be easier to comprehend. Aggregating foods into groups and averaging over nutrient values would necessarily reduce the nutritional accuracy of the solutions. However, the increased fulness of the information for illustrating dietary change may substantially offset this disadvantage.

5.2.2 Second Recommendation

Only information on the client's initial diet inventory, or alternatively a food plan identified as desirable was used to define modifications of that inventory. This was done to limit the amount of information required from the client on the questionnaire. However, the client (or the client's counsellor) could usefully provide information on the relative acceptability of deviating from initial levels in order to more acceptably direct revisions of the diet. For example, the client could indicate whether the relative acceptability of either an increase or decrease in the amount presently consumed (or not consumed) is: high, indeterminate, or low. These responses can then be incorporated into the algorithm's penalty coefficients and/or constraints to adjust the solution outcomes. The initially-assigned values for the penalty coefficients and/or constraints will be arbitrary until the relationship of individual response to coefficient assignment is appropriately indexed.

5.3 Conclusions

The use of mathematical modelling and computer technology has provided an effective means of collating the vast amount of data required to develop cogent dietary recommendations which are nutritionally accurate, straightforward, and potentially acceptable to the individual. The concept of minimizing deviation from an initial dietary inventory seems a feasible approach to establish the link between these mathematical programming techniques and the objectives of diet planning -- that is, to approximate the individual's nutrient-constrained food choice.

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APPENDIX A

FOOD-ITEM FILE

Two hundred and twenty-one item clusters with attribute group code number, item cluster code number, standard portion sizes, and gram equivalents per portion.

ATTRIB.[a] GROUP CODE #	ITEM[b] CLUSTER CODE #	GRAMS[c] PER PORTION	STANDARD PORTION SIZE[d e f]	FOOD ITEMS AND DESCRIPTION
				ENTREE ITEMS - DAIRY AND EGGS
001	001	28	1"-1"-1½" (1 oz.)[d]	AMERICAN PROCESSED CHEESE.
001	002	28	1"-1"-1½" (1 oz.)[d]	BLUE or ROQUEFORT CHEESE.
001	003	28	1"-1"-1½" (1 oz.)[d]	CHEDDAR, JACK or SWISS CHEESE.
001	004	114	½ cup (4 oz.)[d]	COTTAGE CHEESE, creamed or uncreamed, any curd.
001	005	28	2 tbsp. (1 oz.)[d]	CREAM CHEESE or CHEESE SPREADS.
002	006	15	1 tbsp.[d]	SOUR CREAM or CHIP DIP.
002	007	244	1 cup[d]	YOGHURT, base of whole milk (3.5% b.f.)
002	008	246	1 cup[d]	YOGHURT, base of skim milk.
002	009	246	1 cup[d]	YOGHURT, base of part skimmed and 2% nonfat milk solids
003	010	55	1 egg[d]	EGG: raw, boiled, poached, fried (add fat).
003	011	140	2 eggs[d]	EGG: scrambled, omelets, souffles, spoon bread.
				ENTREE ITEMS - CEREALS
004	012	28	1 cup (1 oz.)[d]	CORN CEREAL, enriched, eg. corn flakes: ready-to-eat.
004	013	28	1 cup (1 oz.)[d]	WHEAT CEREAL, enriched, eg. rice krispies: ready-to-eat.
005	014	120	½ cup[d]	WHEAT CEREAL, more refined, eg. cream of wheat: cooked.
005	015	120	½ cup[d]	OATMEAL, all types: cooked.
005	016	120	½ cup[d]	WHEAT CEREAL, less refined, eg. rolled wheat: cooked.
006	017	90	2 at 4" dia.[d]	PANCAKES, WAFFLES or FRITTERS, made with milk and eggs.
007	018	80	½ cup[d]	NOODLES, EGG TYPE, enriched: cooked.
007	019	75	½ cup[d]	SPAGHETTI, MACARONI or NON-EGG PASTAS, enriched: cooked.
008	020	75	½ cup[d]	RICE, BROWN: cooked.
008	021	75	½ cup[d]	RICE, WHITE, enriched, unenriched or parboiled: cooked.
008	022	120	½ cup[d]	CORNMEAL or CORN GRITS, enriched: cooked.
008	023	28	3 tbsp. (1 oz.)[d]	WHEAT GERM.

009	024	20	1 slice (9/16")[d] [f]	FRENCH or SOURDOUGH BREAD, enriched: fresh or toasted.
009	025	23	1 slice (9/16")[d] [f]	RAISIN or RAISIN-NUT BREAD, enriched: fresh or toasted.
009	026	23	1 slice (9/16")[d] [f]	RYE BREAD, light or dark: fresh or toasted.
009	027	23	1 slice (9/16")[d] [f]	WHITE or CRACKED WHEAT BREAD, enriched: fresh or toasted.
009	028	23	1 slice (9/16")[d] [f]	WHOLE WHEAT BREAD: fresh or toasted.
009	029	40	1 square (2"-2"-1¼")[d] [f]	CORN BREAD or JOHNNY CAKE.
009	030	30	1 at 6" dia.[d]	CORN TORTILLAS or FLOUR TORTILLAS.
010	031	35	1 at 2" dia.[e]	BISCUITS, ROLLS or POPOVERS.
010	032	46	1[d]	HAMBURGER BUN, HOT DOG BUN, or BAGEL, enriched.
010	033	40	1[d]	MUFFIN, white, bran, blueberry, brownbread.
010	034	40	1[d]	SOURDOUGH ENGLISH MUFFIN.
010	035	46	1[d]	WHOLE WHEAT ENGLISH MUFFIN.
011	036	14	1 at 5"-2½"-3/16"[f]	GRAHAM CRACKERS, honey-coated or whole wheat.
011	037	6	2 at 1⅞"-1⅞"-1/8"[f]	SODA CRACKERS, saltines, holland rusk, matzoth.
			10 at 3⅛"-1/8" dia.	PRETZELS.
011	038	21	1 cups	POPCORN: popped (add salt and fat is used).
011	039	30	15 chips (1 oz.)[d]	POTATOE CHIPS, FRITOS, CORN PUFFS or TORTILLA CHIPS.
011	040	14	2 at 3½"-1⅞"-¼"[f]	RYE KRISP.
			3[e]	TRISCUITS.
			8[e]	WHEAT THINS.

ENTREE ITEMS - MEATS AND PLANT PROTEIN

012	041	85	1/3 cup (3 oz.)[d]	BEEF, 30% fat cut, eg. chuck rib, veal: cooked.
012	042	85	1/3 cup (3 oz.)[d]	BEEF, 20% fat cut, eg. regular ground hamburger: cooked.
012	043	85	1/3 cup (3 oz.)[d]	BEEF, 15% fat cut, eg. round: cooked.
012	044	85	1/3 cup (3 oz.)[d]	CORNED BEEF, fresh or canned.
012	045	85	1/3 cup (3 oz.)[d]	LAMB, all muscle cuts, eg. leg, shoulder, chops: cooked.
012	046	85	1/3 cup (3 oz.)[d]	PORK, lean cuts, eg. chops, shoulder, roast: cooked.
012	047	85	1/3 cup (3 oz.)[d]	PORK, all hams, fresh or canned.
012	048	16	2 slices[d]	BACON, thick cut, thin cut or slab: cooked, drained.
013	049	85	1/3 cup (3 oz.)[d]	CHICKEN: steamed, stewed, broiled, baked or canned.
013	050	200	1 cup[d]	CHICKEN: prepared with sauce, eg. fricassee, cacciatore.
013	051	85	1/3 cup (3 oz.)[d]	CHICKEN: fried flesh and skin.
013	052	85	1/3 cup (3 oz.)[d]	TURKEY, DUCK, RABBIT or SQUAB GOOSE: roasted.

014	053	100	5 small (3½ oz.)[d]	CLAMS: canned.
014	054	100	4 to 5 sticks (3½ oz.)[d]	FISH STICKS, FISH CAKES, FISH LOAFS: cooked.
014	055	100	(3½ oz.)[d]	FRIED FISH, eg. fried haddock: breaded, fried.
014	056	85	(3 oz.)[d]	BROILED FISH, eg. broiled halibut.
014	057	100	5 to 8 medium (3½ oz.)[d]	OYSTERS: canned.
014	058	100	5 to 8 medium (3½ oz.)[d]	OYSTERS: breaded, fried.
014	059	85	(3 oz.)[d]	SALMON, all types: fresh or frozen, cooked.
014	060	56	(2 oz.)[d]	SALMON, canned.
014	061	85	(3 oz.)[d]	SMOKED FISH, all types, eg. smoked salmon.
014	062	28	2 medium (1 oz.)[d]	SARDINES or KIPPERS: fresh or canned.
014	063	85	(3 oz.)[d]	SHRIMP, LOBSTER, CRAB or ABALONE: fresh or canned.
014	064	100	(3½ oz.)[d]	SHRIMP: fried.
014	065	60	1/3 can (2 oz.)[d]	TUNA: canned, oil or water-pack.
014	066	85	(3 oz.)[d]	RAW FISH, eg. raw tuna.
015	067	85	(3 oz.)[d]	LIVER, beef, calf, hog, chicken or lamb: fried.
016	068	85	(3 oz.)[d]	KIDNEY.
017	069	45		ALL LUNCH MEATS EXCEPT LIVERWURST.
			1 at 5"-¾"[f]	FRANKFURTER: cooked.
			x1.4(1 link at 4"-⅛")[f]	KNOCKWURST.
			x1.1(1 slice at 4"-3"-⅛")[e*]	HEAD CHEESE.
			x1.6(1 slice at 4½"-4½"-⅛")[e]	BOLOGNA.
			3 at 2"-¾" dia.[e]	VIENNA SAUSAGE.
			1 at 3¾"-3¾"-¼"[e]	SALAMI.
			x2.8(1 slice at 4¼"-4¼"-1/16")[f]	LOAF MEAT, eg. ham loaf, olive loaf.
			3 tbsp.[f]	MEAT SPREADS, eg. deviled ham.
017	070	40	2 links at 3"-½" dia.[e]	FRESH COOKED SAUSAGES, eg. pork sausages.
017	071	30	1 slice at 3" dia.-¼"[e]	LIVERWURST or PATE DE FOIS GRAS.
018	072	125	½ cup[d]	BEANS, WHITE, RED, PINTO, KIDNEY: canned.
018	073	100	½ cup (3½ oz.)[d]	BEANS, white, red, pinto or kidney: boiled and drained.
018	074	85	½ cup (3 oz.)[d]	COWPEAS or BLACK-EYED PEAS: boiled and drained.
018	075	75	½ cup[d]	SOYBEANS: boiled and drained.
019	076	15	12 to 15[d e]	ALMONDS.
			10 to 12[e]	FILBERTS or HAZELNUTS.
			2 tbsp.[f]	SESAME SEEDS.
019	077	15	t tbsp.[f]	CASHEW BUTTER.

			6 to 8[d]	CASHEW NUTS.
019	078	30	2 pieces at 1"-1"-⅜"[e]	COCONUT: fresh, shredded or dried.
			⅓ cup shredded[e]	
019	079	28	2 tbsp. (1 oz.)[d]	PEANUT BUTTER and OTHER NUT BUTTERS EXCEPT CASHEWS.
019	080	15	1 tbsp.[d]	PEANUTS or SPANISH PEANUTS.
019	081	15	2 tbsp., 8 to 10 halves[d]	WALNUTS, persian, black or english: PECANS.
				<u>ENTREE ITEMS - VEGETABLES</u>
020	082	100	round: 1 at 2¼" to 2½" dia.[e]	POTATOE, all white types: baked or boiled.
			round: x1.5(1 at 3¼" dia.)[e]	
			long: x2.5(1 at 2⅓" dia-4¾")[f]	
020	083	50	10 pcs. at ½"-½"-2:, cup[e]	POTATOE, all white types: fried, eg. french fried.
020	084	100	½ cup (3½ oz.)[d]	POTATOE, all white types: mashed with fat and milk.
020	085	180	1 at 2" dia.-5:, or ¾ cup[f]	SWEET POTATOE: baked in skin.
020	086	100	1 at 2" dia.-4"[e], or ½ cup[d]	SWEET POTATOE: canned in syrup.
020	087	100	2/5 cup[e]	YAM: baked or boiled.
021	088	100	½ of 3¼" dia.-4"[3], or ½ cup[f]	AVACADO, raw or avacado dip.
021	089	65	½ cup[d]	BEANS, snap green or wax: fresh or frozen, boiled.
021	090	65	½ cup[d]	BEANS, snap green or wax: canned, boiled and drained.
021	091	63	½ cup[d]	BROCCOLI: boiled and drained.
021	092	43	½ cup[d]	CABBAGE, CAULIFLOWER or SAVOY: raw.
021	093	62	½ cup[d]	CABBAGE, BRUSSEL SPROUTS or CAULIFLOWER: boiled, drained.
021	094	85	½ cup[d]	COLLARDS or KALE: boiled, drained.
021	095	37	½ cup chunks[d]	LETTUCE, crisp head, romaine, iceberg or endive: raw.
021	096	100	½ cup[d]	GREENS, mustard or turnip: fresh or frozen, boiled, drained.
021	097	85	½ cup[d]	PEAS, LIMA BEANS or SNOW PEAS: canned, boiled, drained.
021	098	85	½ cup[d]	PEAS, LIMA BEANS or SNOW PEAS: fresh or frozen, boiled.
021	099	62	½ cup[d]	PEPPERS, sweet green: raw, canned or boiled.
021	100	85	½ cup[d]	SPINACH, BOK CHOY, or BEET GREENS: canned, drained.
021	102	27	½ cup[d]	SPINACH: raw.
022	103	80	½ cup[d]	BEETS or ARTICHOKE: raw or canned, cooked, drained.
022	104	76	½ cup[d]	CARROTS or WINTERSQUASH: boiled and drained.
				MATURE RED PEPPERS or HOT CHILI PEPPERS: canned or fresh.
022	105	50	½ lg.(9"-1⅜"), ⅔ med.(7½"-1⅛")[f]	CARROTS: raw.
			1 sml.(5"-⅞"), ½ cup diced[f]	
			½ cup shredded[f]	

022	106	85	½ cup (3 oz.)[d]	CORN: fresh or frozen, boiled and drained.
022	107	126	½ cup[d]	CORN, cream-style: canned
022	108	85	½ cup (3 oz.)[d]	CORN, kernal: canned, boiled and drained.
022	109	100	½ cup (3½ oz.)[d]	SUMMER SQUASH, ASPARAGUS or ZUCCHINI: boiled, drained.
022	110	100	½ cup (3½ oz.)[d]	TOMATO: canned solid and liquid.
022	111	148	1 med.(2¾"), x ¾ sml.(2⅔")[f] x 1½ lrg.(3")[f]	TOMATO: raw
022	112	77	½ cup[d]	TURNIP ROOT or TUTABAGA: boiled and drained.
023	113	50	piece (2⅝" dia.-1½") or (1¾" dia.-2")[f]	CUCUMBER: raw.
			1 lrg. stalk(8"-1¼") or 3 sml. stalks(5"-¾")[f]	CELERY: raw
			10(¾" to 1") or 6(1" to 1¼")[f]	RADISHES: raw
023	114	100	½ cup (3½ oz.)[d]	MUSHROOMS or WATER CHESTNUT: fresh or canned, cooked.
023	115	45	¼ cup[d]	ONIONS, LEEKS, GARLIC or GREEN ONIONS: raw or boiled.
024	116	85	½ cup (3 oz.)[d]	MIXED VEGETABLES or SUCCOTASH: frozen, boiled.
025	117	13	4(⅝" dia.13/16"), 3(6/8" dia.-15/16), 2(⅞" dia.-1⅛")[f]	OLIVES, green, black or stuffed.
025	118	20	1(1" dia.-3¼"), 1(1" dia.-1¾"), 3(1½" dia.-¼"), overful tbsp.[f]	PICKLES, sweet, bread and butter or pickle relish.
025	119	34	¼ lrg.(1¾" dia.-4"), ¼ cup, ½ med.(1¼" dia.-3¾"), 5(1½" dia.-¼")[f]	PICKLES, dill or sour.
				<u>ENTREE ITEMS - FATS AND OILS</u>
026	120	15	1 tbsp.[d]	VEGETABLE FAT, eg. crisco or hardened shortening.
026	121	15	1 tbsp.[d]	LARD, SUET or SALT PORK.
026	122	15	1 tbsp.[d]	COTTONSEED OIL.
026	123	15	1 tbsp.[d]	OLIVE OIL.
026	124	15	1 tbsp.[d]	SOYBEAN or CORN OIL.
027	125	5	1 tsp.[d]	BUTTER, sweet or salted butter.
027	126	5	1 tsp.[d]	MARGARINE, all brands, whipped or diet.
028	127	38	2 tbsp.[d]	CHEESE SAUCE or FONDUE.

028	128	72	4 tbsp., or ¼ cup[d]	GRAVY, all types.
028	129	33	1 tbsp.[d]	WHITE SAUCE, thick or thin, or HOLLANDAISE SAUCE.
028	130	17	1 tbsp.[d]	TOMATO CATSUP or BARBECUE SAUCE.
028	131	100	½ cup[d]	TOMATO SAUCE.
029	132	15	1 tbsp.[d]	MAYONNAISE, SANDWICH SPREAD or TARTAR SAUCE.
029	133	15	1 tbsp.[d]	SALAD DRESSING, oil types, eg. italian.
029	134	15	1 tbsp.[d]	SALAD DRESSING, mayonnaise type, eg. thousand island.
029	135	14	1 tbsp.[d]	ROQUEFORT or BLUE CHEESE SALAD DRESSING.
				BEVERAGES - DAIRY
030	136	244	1 cup (8 fl. oz.)[d]	WHOLE MILK, 3.5% b.f.
030	137	246	1 cup (8 fl. oz.)[d]	SKIM MILK, BUTTERMILK or NONFAT INSTANT MILK.
030	138	246	1 cup (8 fl. oz.)[d]	PART SKIM and 2% NONFAT MILK SOLIDS.
031	139	121	1 cup[d]	HALF AND HALF.
031	140	15	1 tbsp.[d]	LIGHT TABLE CREAM and NONDAIRY COFFEE WHITENERS.
031	141	8	1 tbsp. whipped, 2 tbsp. unwhipped[d]	WHIPPED CREAM, COOL WHIP or IMITATION TOPPINGS.
031	142	15	1 tbsp.[d]	CANNED EVAPORATED or CONDENSED MILK, sweet or unsweet.
				BEVERAGES - FRUIT and VEGETABLE
032	143	120	½ cup (4 fl. oz.)[d]	APPLE, GRAPE, PRUNE, or PEAR JUICE: fresh, frozen, canned.
032	144	120	½ cup (4 fl. oz.)[d]	GRAPEFRUIT JUICE: canned and unsweetened.
032	145	15	1 tbsp, or ⅓ lemon[d]	LEMON, LIME or ACEROLA JUICE: fresh, frozen or canned.
032	146	226	1 cup (8 fl. oz.)[d]	FRESH LEMONADE, ALL FRUIT ADES and ARTIFICIAL LEMONADES.
032	147	120	½ cup (4 fl. oz.)[d]	ORANGE JUICE: canned.
032	148	120	½ cup (4 fl. oz.)[d]	ORANGE JUICE: frozen.
032	149	120	½ cup (4 fl. oz.)[d]	ORANGE JUICE: fresh.
033	150	100	½ cup (4 fl. oz.)[d]	TOMATOE JUICE or VEGETABLE JUICE: canned.
				BEVERAGES - MISCELLANEOUS
034	151	339	12 fl. oz.[d]	COLA-TYPE BEVERAGES, caffeine-containing, carbonated.
034	152	339	12 fl. oz.[d]	GINGER ALE, non-caffeine containing, carbonated.

035	153	200	1 cup[d]	COFFEE, all types.
035	154	200	1 cup[d]	TEA, all types.
036	155	360	12 fl. oz.[d]	BEER, ALE, or STOUT.
036	156	43	1.5 oz. jigger[d]	DISTILLED SPIRITS, eg. gin, rum, whiskey or vodka.
036	157	60	2 fl. oz., sherry glass[d]	DESSERT or SWEET WINE
036	158	100	3.5 fl. oz., wine glass[d]	TABLE or DRY WINE.

<u>SOUPS</u>

037	159	198	8/10 cup, can[d] [f]	NOODLE or RICE SOUPS WITH MEAT: canned, dry or instant.
037	160	198	8/10 cup, can[d] [f]	CREAMED SOUPS MADE WITH MILK: canned, dry or instant.
037	161	200	8/10 cup, can[d] [f]	PEA or BEAN SOUP: canned, dry or instant.
037	162	198	8/10 cup, can[d] [f]	TOMATOE SOUP WITH OR WITHOUT RICE.
037	163	203	8/10 cup, can[d] [f]	MEAT AND VEGETABLE AND VEGETARIAN VEGETABLE SOUPS.
037	164	200	8/10 cup[d]	ONION SOUP or CONSOMME.

<u>DESSERTS AND SWEETS - CEREALS</u>

038	165	45	1⅞" arc of cake 9¾" dia.-4"[f] or x1.35 of 2½" arc[f]	ANGEL FOOD CAKE, SPONGE CAKE or TWINKES.
038	166	75	1 piece 3"-2½"-1¼"[f]	COFFEE CAKE, BANANA BREAD, DATE-NUT BREAD or SNAKIN CAKE.
038	167	55	1 " arc of cake 8" dia.-3"[f]	CHOCOLATE CAKE WITH ICING.
			x1¼(2¾" dia.), x1.65(2½" dia.)[f]	CUPCAKE WITH FROSTING.
			square 2"-2"-1⅜"[f]	BROWNIE.
038	168	40	1 piece 3"-3"-½"[e]*	FRUITCAKE, light or dark.
038	169	30	1 piece 3"-3"-½"[f]	POUND CAKE.
038	170	60	1⅝" arc cake 8" dia-3"[f]	ALL OTHER COMMERCIAL, HOMEMADE or FROZEN CAKE WITH ICING.
039	171	160	4¾" arc 9" dia., 1/6th[f]	ALL FRUIT PIES, eg. apple, pecan, lemon meringue.
039	172	150	4¾" arc 9" dia., 1/6th[f]	PUMPKIN or SWEET POTATOE PIE.
040	173	40	2 cookies[d]	ALL COOKIES WITHOUT FRUIT FILLING, eg. sandwich-type. ICE CREAM CONE or COOKIE OF ICE-CREAM SANDWICH.
040	174	29	2 bars[d]	ALL FRUIT-FILLED COOKIES, eg. figbars or raisin cookies.
041	175	30	1 average[d]	CAKE DOUGHNUT, iced or uniced.
041	176	30	1 average[d]	YEAST-RAISED DOUGHNUT, iced or uniced.

041	177	38	1[d]	DANISH PASTRY or HOT CROSS BUN.
			x 1.6(1)[d]	CINNAMON BUN or SWEET ROLL.
				<u>DESSERTS AND SWEETS - DAIRY</u>
042	178	90	½ cup[d]	ICE CREAM, ICE MILK or ICE CREAM BARS, all flavors.
042	179	97	½ cup[d]	SHERBERT, all flavors.
042	180	339	1[d]	POPSICLE.
043	181	130	½ cup[d]	TAPIOCA and RICE PUDDING, JUNKET, CUSTARD or PIE FILLING.
043	182	246	1 cup[d]	YOGHURT, add fruit and sugar if included.
				<u>DESSERTS AND SWEETS - FRUIT</u>
044	183	150	1(2¾" dia.), x 1½(3¼" dia.), or x ¾(2½" dia.)[f]	APPLE, raw.
			1(3½" long-2½" dia.)[e f]	PEAR, raw.
			1 cup, 20(⅞" dia.)[f]	GRAPES, raw.
			1 cup, 3(2⅛" dia.), 4(1½" dia.)[f]	PLUMS, raw.
			20[f]	CHERRIES, raw.
			1/3 (10" dia.-1" slice)[f]	WATERMELON, raw.
			½(6" dia.-1½" slice)[e]	HONEYDEW MELON or CASABA MELON, raw.
044	184	130	½ cup[d e]	APPLESAUCE: fresh or canned.
			½ cup[d e]	PEARS, GRAPES, PLUMS or CHERRIES: canned.
044	185	100	1 sml.(6"), x 1½med.(8"), ⅔ cup[e f]	BANANA or PLANTAIN.
044	186	100	¼ of 5" dia.[e]	CANTALOUPE.
044	187	100	½ of 4" dia.[e]	GRAPEFRUIT, fresh or unsweetened.
044	188	100	1 sml. (2½" dia.)[e] x 1½ med.(3" dia.)[e] x 2.35 lrg.(3⅜" dia.)[e]	ORANGE, raw.
			10 lrg., 2/3 cup[e]	STRAWBERRIES, raw.
044	189	126	½ cup[e]	PEACHES, APRICOTS or FRUIT COCKTAIL, heavy syrup pack.
044	190	100	1 at 2½" dia., 1¾ (2¾")[f]	PEACHES, PERSIMMONS or NECTARINES, raw.
			2 or 3[e f]	APRICOTS, raw.
044	191	139	½ cup[d]	PINEAPPLE, MANDARIN ORANGE or BOYSENBERRIES, heavy syrup.
044	192	80	½ cup[d]	PINEAPPLE, TANGERINES or BOYSENBERRIES, water or juice pack.
045	193	28	2 tbsp. (1 oz.)[d]	RAISINS, PRUNES or OTHER DRIED FRUIT, not peaches or apric.

046	194	80	½ cup[d]	GELATIN DESSERT, with or without fruit.
				<u>DESSERTS AND SWEETS - SWEETS</u>
047	195	21	1 tbsp.[d]	HONEY, all type.
047	196	20	1 tbsp.[d]	MOLASSES, all types.
047	197	5	1 tsp.[d]	SUGAR.
048	198	20	1 tbsp.[d]	JELLIES, PRESERVES, JAM or MARMALADES.
048	199	20	1 tbsp.[d]	CORN SYRUP or MAPLE SYRUP.
049	200	28	1 piece (1"-1"-1⅜"), (1oz.)[f] 1 piece (2"-2"-⅜")[f] 3 caramels[e]	CARAMEL CANDY, TAFFY or VANILLA-COATED CARAMELS.
049	201	28	1 piece (2"-2"-⅜"), (1 oz.)[f] 1 piece (1"-1"-1⅜")[f]	CHOCOLATE CANDY, MILK CHOCOLATE or FUDGE.
			2(1¾" dia.-⅜"), 10(¾" dia.-⅜")[f]	CHOCOLATE DISK.
			(1 oz.)[d]	CHOCOLATE SYRUP or FUDGE TOPPING.
049	202	15	2 lrg. (1⅛" dia.)	MARSHMALLOW.
			1 piece (1"-1"-¾"), 2 hard[e]	HARD CANDY.
			3 lrg., 6 sml.[e]	MARASHINO CHERRIES.
			-----	CHEWING GUM
049	203	20	7[f]	JELLY BEANS.
			2 lrg. (⅞" dia.), 16 sml.[f]	GUM DROPS or JELLY CANDIES.
				<u>MISCELLANEOUS ITEMS</u>
050	204	125	½ cup[d]	BEANS WITH PORK AND TOMATOE SAUCE, canned or homemade.
051	205	227	1(4¼" dia.), or 1/3(9" dia.)[f]	POT PIES, chicken or tuna: commercial or homemade.
052	206	238	1 cup[d]	MEAT AND VEGETABLE STEWS.
053	207	220	1 cup[d]	CHOW MEIN or CHOP SUEY: canned or frozen.
054	208	220	1 cup[d]	CHOW MEIN or CHOP SUEY: homemade.
055	209	224	1 cup[d]	CHILI CON CARNE WITH OR WITHOUT BEANS, canned.

056	210	312	1 dinner, (11 oz.)[d]	FROZEN DINNER: fried chicken, mashed potatoes and peas.
057	211	312	1 dinner, (11 oz.)[d]	FROZEN DINNER: meatloaf, mashed potatoes and peas.
058	212	300	1 dinner, (11 oz.)[d]	FROZEN DINNER: roast turkey, mashed potatoes and peas.
059	213	224	½ cup[d]	HASHES, CANNED CORNBEEF or ANY HOMEMADE HASH.
060	214	225	½ cup[d]	MACARONI AND CHEESE: homemade, packaged or frozen.
061	215	200	3/8 of 14" pizza[f] 3 (5½" dia.) sector, (7 oz.)[f]	PIZZA, any kind.
062	216	200	1 cup[d]	SPAGHETTI IN TOMATOE SAUCE, CANNED RAVIOLI or NOODLE-O'S.
063	217	220	1 cup[d]	SPAGHETTI WITH MEAT BALLS: homemade or packaged.
064	218	155	2 from can of 6[d]	TAMALES: homemade or canned.
065	219	4	1 cube[d]	BOULLION CUBE.
066	220	1	1 tsp.[d]	TABLE SALT or MONO-SODIUM GLUTAMATE.
067	221	7	1 tbsp.[d]	COCOA MIX.

[a] For the legend of group codes, see Appendix G of this text.

[b] A food item cluster is one item or two or more specific items, item varieties, or prepared variations of an item with common nutrient characteristics. Item clusters are numbered in the sequence they appear in the food item file. The food items list is adapted from Mini List Foods and Food Substitutions in Pennington, J.A., Dietary Nutrient Guide, AVI Publishing Co., Westport, Connecticut, 1976.

[c] Gram equivalents per portion are from Mini List Foods, Appendix C, Pennington, J.A., Dietary Nutrient Guide, AVI Publishing Co., Westport, Connecticut, 1976.

[d] Standard portion size derived from Mini List Foods, Appendix C, in Pennington, J.A., Dietary Nutrient Guide, AVI Publishing Co., Westport, Connecticut, 1976.

[e] Standard portion size derived from Church, C.F. and Church, H.N., Food Values of Portions Commonly Used, 12th edition, J.B. Lippincott Co., New York, 1975.

[f] Standard portion size derived from Adams, G.F., Nutritive Value of American Foods in Common Units, Agriculture Handbook No. 456, U.S.D.A., 1975.

* Description of standard portions per gram quantity differ between [e] and [f].

APPENDIX B

ABRIDGED FOOD-ITEM FILE

Listing, by group code and item cluster code, of 127 item clusters selected from Appendix A.

ATTRIBUTE[a] GROUP CODE #	ITEM CLUSTER CODE #	ATTRIBUTE CLUSTER CODE #	ITEM CLUSTER CODE #	ATTRIBUTE GROUP CODE #	ITEM CLUSTER CODE #
001	003	020	082	038	170
001	004	020	083	039	171
001	005	020	084	039	172
002	006	020	085	040	173
002	008	021	089	040	174
003	010	021	091	041	175
004	012	021	092	041	177
004	013	021	095	042	178
005	015	021	098	042	179
005	016	021	099	043	181
006	017	021	101	044	183
007	018	022	103	044	184
007	019	022	104	044	185
008	020	022	105	044	186
008	021	022	106	044	187
008	023	022	111	044	188
009	024	023	113	044	192
009	027	023	114	045	193
009	028	023	115	047	195
010	031	024	116	047	197
010	032	025	117	048	198
010	033	025	118	048	199
010	035	025	119	049	201
011	037	026	121	049	202
011	040	026	124	051	205
012	041	027	125	063	217
012	042	028	127	067	221
012	043	028	128		
012	046	029	132		
012	047	029	133		
012	048	030	136		
013	049	030	137		
013	051	031	140		
014	055	031	141		
014	056	032	143		
014	058	032	144		
014	062	032	145		
014	063	032	148		
014	065	033	150		
015	067	034	151		
017	069	035	153		
017	070	035	154		
017	071	036	155		
018	073	036	156		
018	075	036	158		
019	076	037	160		
019	077	037	161		
019	079	037	163		
019	080	038	166		
019	081	038	168		

[a] Refer to Appendix A for description of item clusters, standard portion sizes, and gram equivalents per portion associated with each of the coded items.

APPENDIX C

FOOD-COMPOSITION FILE

Table of 41 nutrient values, in nutrients per 100 grams of edible portions of food, for 221 item clusters indexed by attribute group code and item cluster code number.

ITEM CLUSTER[a]		1	2	3	4	5
ATTRIBUTE GROUP		1	1	1	1	1
NUTRIENTS:[b]						
KCAL		370.000	368.000	398.000	106.000	374.000
PROT	(GM)	23.20C	21.500	25.000	13.600	8.000
TRY	(MG)	320.000	290.000	320.000	150.000	70.000
THR	(MG)	840.00C	810.000	860.000	640.000	350.000
ISO	(MG)	1540.0CC	1480.000	1560.000	790.000	460.000
LEU	(MG)	2230.00C	2140.000	2260.000	1470.000	800.000
LYS	(MG)	1670.0CC	1550.000	1700.000	1140.000	630.000
MET	(MG)	600.000	580.000	600.000	380.000	200.000
CYS	(MG)	130.00C	120.000	130.000	120.000	80.000
PHE	(MG)	1200.000	1200.000	1300.000	760.000	500.000
TYR	(MG)	1110.00C	1030.000	1110.000	730.000	360.000
VAL	(MG)	1640.000	1580.000	1670.000	780.000	470.000
HIS	(MG)	760.000	700.000	760.000	440.000	250.000
FAT-T	(GM)	30.00C	30.500	32.200	4.200	37.700
SFA	(GM)	15.000	17.000	18.000	2.000	21.000
PUFA	(GM)	10.0CC	11.000	12.000	1.000	13.000
CHOLE	(GM)	0.150	0.150	0.120	0.015	0.120
CHO-T	(GM)	1.900	2.000	2.100	2.900	2.100
SUCR	(GM)	0.0	0.0	0.0	0.0	0.0
CHO-F	(GM)	0.0	0.0	0.0	0.0	0.0
THIA	(MG)	0.02C	0.030	0.030	0.030	0.020
RIBO	(MG)	0.41C	0.610	0.460	0.250	0.240
NIACIN	(MG)	0.0	1.200	C.100	0.100	0.100
VIT-B6	(MG)	80.00C	170.000	80.000	40.000	60.000
FOLIC	(UG)	11.000	11.000	6.000	27.000	16.000
VIT-B12	(UG)	1.00C	1.400	1.000	1.000	0.220
VIT-C	(MG)	0.0	0.0	0.0	0.0	0.0
PANTO	(UG)	500.000	1800.000	500.000	200.000	300.000
BIOTIN	(MG)	5.00C	3.000	2.000	2.000	1.000
VIT-A	(IU)	1220.00C	1240.0C0	1310.000	170.000	1540.000
VIT-D	(IU)	30.00C	30.000	30.000	4.000	30.000
VIT-E	(MG)	1.00C	0.800	1.300	0.100	1.000
CA	(MG)	697.000	315.000	750.000	94.000	62.000
P	(MG)	771.000	339.000	478.000	152.000	95.000
MG	(MG)	48.000	20.000	37.000	8.000	5.000
FE	(MG)	0.900	0.500	1.000	0.300	0.200
I	(MG)	11.00C	11.0C0	11.000	6.000	4.000
ZN	(MG)	4.10C	2.200	0.900	1.400	0.800
NA	(MG)	1136.0CC	666.000	700.000	229.000	250.000
K	(MG)	80.000	78.000	82.000	85.000	74.000
CU	(MG)	0.17C	0.160	0.130	0.020	0.040

[a] See Appendix A of this text for definition of item cluster and the items associated with the attribute group code and item code numbers.

[b] Values of nutrient composition obtained from Mini List Foods, Appendix B, Pennington, J.A., Dietary Nutrient Guide, The AVI Publishing Co., Westport, Connecticut, 1976.

ITEM CLUSTER		6	7	8	9	10
ATTRIBUTE GROUP		2	2	2	2	3
NUTRIENTS:						
KCAL		211.000	65.000	36.000	59.000	163.000
PROT	(GM)	3.00C	3.500	3.600	4.200	12.900
TRY	(MG)	40.00C	50.000	50.000	60.000	210.000
THR	(MG)	140.000	160.000	160.000	190.000	640.000
ISO	(MG)	190.000	230.000	190.000	270.000	850.000
LEU	(MG)	300.000	350.000	360.000	420.000	1100.000
LYS	(MG)	230.00C	280.000	280.000	330.000	820.000
MET	(MG)	70.000	80.000	90.000	100.000	400.000
CYS	(MG)	30.00C	30.000	30.000	40.000	300.000
PHE	(MG)	150.000	170.000	170.000	200.000	740.000
TYR	(MG)	150.0CC	180.000	180.000	200.000	550.000
VAL	(MG)	210.0CC	240.000	250.000	290.000	950.000
HIS	(MG)	80.000	90.000	100.000	110.000	310.000
FAT-T	(GM)	20.600	3.500	0.100	2.000	11.500
SFA	(GM)	11.000	2.000	0.0	1.000	4.000
PUFA	(GM)	8.00C	1.000	0.0	1.000	6.000
CHOLE	(GM)	0.070	0.014	0.002	0.002	0.550
CHO-T	(GM)	4.30C	4.900	5.100	6.000	0.900
SUCR	(GM)	0.0	0.0	0.0	0.0	0.0
CHO-F	(GM)	0.0	0.0	0.0	0.0	0.0
THIA	(MG)	0.030	0.030	0.040	0.040	0.090
RIBO	(MG)	0.150	0.170	0.180	0.210	0.280
NIACIN	(MG)	0.100	0.100	0.100	0.100	0.100
VIT-B6	(MG)	30.000	40.000	40.000	40.000	90.000
FOLIC	(UG)	20.000	9.000	9.000	9.000	30.000
VIT-B12	(UG)	0.250	0.400	0.400	0.400	2.000
VIT-C	(MG)	1.000	1.000	1.000	1.000	0.0
PANTO	(UG)	300.00C	300.000	400.000	400.000	2000.000
BIOTIN	(MG)	4.00C	4.000	2.000	3.000	23.000
VIT-A	(IU)	840.000	140.000	0.0	80.000	1180.000
VIT-D	(IU)	15.000	41.000	41.000	41.000	50.000
VIT-E	(MG)	0.70C	0.100	0.0	0.100	1.000
CA	(MG)	102.000	118.000	121.000	143.000	54.000
P	(MG)	80.0CC	93.000	95.000	112.000	205.000
MG	(MG)	10.00C	13.000	15.000	17.000	12.000
FE	(MG)	0.0	0.0	0.0	0.100	2.300
I	(MG)	6.00C	7.000	7.000	80.000	14.000
ZN	(MG)	0.300	0.400	0.400	0.400	1.400
NA	(MG)	43.00C	50.000	52.000	61.000	122.000
K	(MG)	122.000	144.000	145.000	175.000	129.000
CU	(MG)	0.170	0.150	0.020	0.020	0.070

ITEM CLUSTER		11	12	13	14	15
ATTRIBUTE GROUP		3	4	4	5	5
NUTRIENTS:						
KCAL		173.000	386.000	354.000	42.000	55.000
PROT	(GM)	11.200	7.900	10.200	1.300	2.000
TRY	(MG)	180.000	60.000	120.000	20.000	30.000
THR	(MG)	550.000	290.000	340.000	20.000	70.000
ISO	(MG)	740.000	320.000	470.000	70.000	130.000
LEU	(MG)	970.000	1090.000	840.000	100.000	150.000
LYS	(MG)	710.000	160.000	340.000	20.000	70.000
MET	(MG)	350.000	140.000	120.000	20.000	30.000
CYS	(MG)	260.000	150.000	180.000	20.000	40.000
PHE	(MG)	690.000	360.000	500.000	60.000	110.000
TYR	(MG)	480.000	280.000	300.000	50.000	70.000
VAL	(MG)	820.000	400.000	540.000	20.000	120.000
HIS	(MG)	270.000	220.000	220.000	30.000	40.000
FAT-T	(GM)	12.900	0.400	1.600	0.100	1.000
SFA	(GM)	5.000	0.0	0.0	0.0	3.000
PUFA	(GM)	7.000	0.0	1.000	0.0	6.000
CHOLE	(GM)	0.380	0.0	0.0	0.0	0.0
CHO-T	(GM)	2.400	85.300	80.500	8.700	9.700
SUCR	(GM)	0.0	23.600	20.100	0.0	0.0
CHO-F	(GM)	0.0	0.700	1.600	0.0	0.200
THIA	(MG)	0.080	0.430	0.640	0.040	0.080
RIBO	(MG)	0.280	0.080	0.140	0.030	0.020
NIACIN	(MG)	0.100	2.100	4.900	0.400	0.100
VIT-B6	(MG)	90.000	70.000	290.000	10.000	20.000
FOLIC	(UG)	19.000	5.000	18.000	0.0	11.000
VIT-B12	(UG)	2.000	0.0	0.0	0.0	0.0
VIT-C	(MG)	0.0	0.0	0.0	0.0	0.0
PANTO	(UG)	2300.000	200.000	500.000	100.000	200.000
BIOTIN	(MG)	17.000	1.000	1.000	16.000	24.000
VIT-A	(IU)	1080.000	0.0	0.0	0.0	0.0
VIT-D	(IU)	50.000	0.0	0.0	0.0	0.0
VIT-E	(MG)	1.000	0.100	0.500	0.0	0.200
CA	(MG)	80.000	17.000	41.000	4.000	9.000
P	(MG)	189.000	45.000	309.000	12.000	57.000
MG	(MG)	12.000	14.000	96.000	3.000	24.000
FE	(MG)	1.700	1.400	4.400	0.300	0.600
I	(MG)	13.000	14.000	14.000	1.000	1.000
ZN	(MG)	1.200	0.400	2.400	0.100	0.900
NA	(MG)	257.000	1005.000	1032.000	144.000	218.000
K	(MG)	146.000	120.000	120.000	9.000	61.000
CU	(MG)	0.050	0.130	0.450	0.030	0.030

ITEM CLUSTER		16	17	18	19	20
ATTRIBUTE GROUP		5	6	7	7	8
NUTRIENTS:						
KCAL		75.000	225.000	125.000	111.000	119.000
PROT	(GM)	2.200	7.200	4.100	3.400	2.500
TRY	(MG)	30.000	100.000	50.000	40.000	20.000
THR	(MG)	70.000	280.000	170.000	130.000	100.000
ISO	(MG)	140.000	400.000	200.000	160.000	120.000
LEU	(MG)	160.000	610.000	270.000	210.000	220.000
LYS	(MG)	40.000	340.000	140.000	100.000	100.000
MET	(MG)	30.000	150.000	70.000	50.000	50.000
CYS	(MG)	40.000	190.000	80.000	70.000	20.000
PHE	(MG)	10.000	390.000	200.000	180.000	130.000
TYR	(MG)	90.000	310.000	100.000	110.000	100.000
VAL	(MG)	130.000	410.000	240.000	180.000	180.000
HIS	(MG)	500.000	170.000	100.000	80.000	30.000
FAT-T	(GM)	0.400	7.300	1.500	0.400	0.600
SFA	(GM)	0.0	3.000	0.0	0.0	0.0
PUFA	(GM)	0.0	5.000	1.000	0.0	0.0
CHOLE	(GM)	0.0	0.070	0.040	0.0	0.0
CHO-T	(GM)	16.900	32.400	23.300	23.000	25.500
SUCR	(GM)	0.0	0.100	0.100	0.100	0.300
CHO-F	(GM)	0.500	0.100	0.100	0.100	0.300
THIA	(MG)	0.070	0.150	0.140	0.140	0.090
RIBO	(MG)	0.030	0.240	0.080	0.080	0.020
NIACIN	(MG)	0.900	0.800	1.200	1.100	1.400
VIT-B6	(MG)	90.000	40.000	20.000	20.000	170.000
FOLIC	(UG)	7.000	8.000	2.000	2.000	7.000
VIT-B12	(UG)	0.0	0.0	0.0	0.0	0.0
VIT-C	(MG)	0.0	0.0	0.0	0.0	0.0
PANTO	(UG)	200.000	700.000	200.000	100.000	400.000
BIOTIN	(MG)	16.000	5.000	2.000	0.0	12.000
VIT-A	(IU)	0.0	250.000	70.000	0.0	0.0
VIT-D	(IU)	0.0	7.000	1.000	0.0	0.0
VIT-E	(MG)	0.300	0.900	0.400	0.400	0.200
CA	(MG)	8.000	215.000	10.000	8.000	12.000
P	(MG)	76.000	260.000	59.000	50.000	73.000
MG	(MG)	31.000	14.000	23.000	13.000	29.000
FE	(MG)	0.700	1.200	0.900	0.900	0.500
I	(MG)	3.000	6.000	1.000	1.000	2.000
ZN	(MG)	0.900	0.600	0.600	0.100	0.300
NA	(MG)	0.0	564.000	2.000	1.000	282.000
K	(MG)	84.000	154.000	44.000	61.000	70.000
CU	(MG)	0.280	0.050	0.010	0.050	0.110

ITEM CLUSTER		21	22	23	24	25
ATTRIBUTE GROUP		8	8	8	9	9
NUTRIENTS:						
KCAL		109.000	50.000	363.000	290.000	262.000
PROT	(GM)	2.000	1.100	26.600	9.100	6.600
TRY	(MG)	20.000	10.000	270.000	110.000	80.000
THR	(MG)	80.000	40.000	1410.000	260.000	130.000
ISO	(MG)	90.000	30.000	1250.000	410.000	280.000
LEU	(MG)	170.000	140.000	1810.000	700.000	440.000
LYS	(MG)	80.000	30.000	1620.000	210.000	170.000
MET	(MG)	40.000	20.000	430.000	120.000	100.000
CYS	(MG)	30.000	10.000	310.000	200.000	150.000
PHE	(MG)	100.000	50.000	1000.000	500.000	360.000
TYR	(MG)	90.000	70.000	940.000	260.000	190.000
VAL	(MG)	140.000	60.000	1440.000	390.000	300.000
HIS	(MG)	30.000	20.000	730.000	340.000	250.000
FAT-T	(GM)	0.100	0.200	10.900	3.000	2.800
SFA	(GM)	0.0	0.0	2.000	1.000	1.000
PUFA	(GM)	0.0	0.0	8.000	1.000	1.000
CHOLE	(GM)	0.0	0.0	0.0	0.004	0.004
CHO-T	(GM)	24.200	10.700	46.700	55.400	53.600
SUCR	(GM)	0.100	0.200	1.000	1.000	4.100
CHO-F	(GM)	0.100	0.100	2.500	0.200	0.900
THIA	(MG)	0.110	0.060	2.010	0.280	0.050
RIBO	(MG)	0.010	0.040	0.680	0.220	0.090
NIACIN	(MG)	1.000	0.500	4.200	2.500	0.700
VIT-B6	(MG)	40.000	30.000	920.000	50.000	40.000
FOLIC	(UG)	1.000	1.000	305.000	9.000	17.000
VIT-B12	(UG)	0.0	0.0	0.0	0.0	0.0
VIT-C	(MG)	0.0	0.0	0.0	0.0	0.0
PANTO	(UG)	200.000	100.000	2200.000	400.000	400.000
BIOTIN	(MG)	5.000	7.000	20.000	1.000	1.000
VIT-A	(IU)	0.0	60.000	0.0	0.0	0.0
VIT-D	(IU)	0.0	0.0	0.0	0.0	0.0
VIT-E	(MG)	0.100	0.100	13.500	0.100	0.100
CA	(MG)	10.000	1.000	72.000	43.000	71.000
P	(MG)	28.000	14.000	1118.000	85.000	87.000
MG	(MG)	6.000	8.000	323.000	22.000	24.000
FE	(MG)	0.900	0.400	9.400	2.200	1.300
I	(MG)	1.000	2.000	2.000	9.000	9.000
ZN	(MG)	0.200	0.200	13.200	1.400	1.200
NA	(MG)	374.000	0.0	3.000	580.000	365.000
K	(MG)	28.000	16.000	827.000	90.000	233.000
CU	(MG)	0.050	0.030	2.910	0.230	0.230

ITEM CLUSTER		26	27	28	29	30
ATTRIBUTE GROUP		9	9	9	9	9
NUTRIENTS:						
KCAL		243.000	270.000	243.000	207.000	210.000
PROT	(GM)	9.100	8.700	10.500	7.400	5.000
TRY	(MG)	100.000	100.000	140.000	70.000	30.000
THR	(MG)	290.000	270.000	320.000	270.000	200.000
ISO	(MG)	390.000	420.000	480.000	350.000	290.000
LEU	(MG)	620.000	690.000	760.000	660.000	810.000
LYS	(MG)	290.000	260.000	290.000	360.000	130.000
MET	(MG)	140.000	130.000	160.000	130.000	70.000
CYS	(MG)	200.000	200.000	240.000	70.000	50.000
PHE	(MG)	500.000	480.000	570.000	400.000	210.000
TYR	(MG)	260.000	250.000	400.000	330.000	90.000
VAL	(MG)	480.000	400.000	500.000	380.000	260.000
HIS	(MG)	350.000	330.000	220.000	150.000	70.000
FAT-T	(GM)	1.100	3.200	3.000	7.200	2.000
SFA	(GM)	0.0	1.000	1.000	2.000	1.000
PUFA	(GM)	1.000	2.000	1.000	4.000	1.000
CHOLE	(GM)	0.004	0.005	0.005	0.006	0.0
CHO-T	(GM)	52.100	50.500	47.700	29.100	45.000
SUCR	(GM)	1.000	1.000	1.000	1.000	0.700
CHO-F	(GM)	0.400	0.200	1.600	0.500	1.000
THIA	(MG)	0.180	0.250	0.260	0.130	0.130
RIBO	(MG)	0.070	0.210	0.120	0.190	0.050
NIACIN	(MG)	1.400	2.400	2.800	0.600	1.000
VIT-B6	(MG)	100.000	40.000	180.000	110.000	70.000
FOLIC	(UG)	38.000	17.000	38.000	4.000	1.000
VIT-B12	(UG)	0.0	0.0	0.0	0.0	0.0
VIT-C	(MG)	0.0	0.0	0.0	1.000	0.0
PANTO	(UG)	500.000	400.000	800.000	300.000	100.000
BIOTIN	(MG)	1.000	1.000	2.000	1.000	2.000
VIT-A	(IU)	0.0	0.0	0.0	150.000	20.000
VIT-D	(IU)	0.0	15.000	8.000	5.000	0.0
VIT-E	(MG)	0.300	0.100	0.400	0.200	0.100
CA	(MG)	75.000	84.000	99.000	120.000	200.000
P	(MG)	147.000	97.000	228.000	211.000	140.000
MG	(MG)	42.000	26.000	45.000	15.000	107.000
FE	(MG)	1.600	2.500	2.300	1.100	3.000
I	(MG)	9.000	9.000	11.000	5.000	6.000
ZN	(MG)	1.600	1.300	2.800	0.700	0.100
NA	(MG)	557.000	507.000	527.000	628.000	110.000
K	(MG)	145.000	105.000	273.000	157.000	16.000
CU	(MG)	0.220	0.230	0.220	0.080	0.190

ITEM CLUSTER		31	32	33	34	35
ATTRIBUTE GROUP		10	10	10	10	10
NUTRIENTS:						
KCAL		325.000	270.000	294.000	290.000	243.000
PROT	(GM)	7.100	8.700	7.800	9.100	10.500
TRY	(MG)	90.000	100.000	100.000	110.000	140.000
THR	(MG)	210.000	270.000	280.000	260.000	320.000
ISO	(MG)	330.000	420.000	420.000	410.000	480.000
LEU	(MG)	550.000	690.000	650.000	700.000	760.000
LYS	(MG)	160.000	260.000	330.000	210.000	290.000
MET	(MG)	90.000	130.000	140.000	120.000	160.000
CYS	(MG)	140.000	200.000	170.000	200.000	240.000
PHE	(MG)	390.000	480.000	430.000	500.000	570.000
TYR	(MG)	230.000	250.000	290.000	260.000	400.000
VAL	(MG)	310.000	400.000	40.000	390.000	500.000
HIS	(MG)	130.000	330.000	150.000	340.000	220.000
FAT-T	(GM)	9.300	3.200	10.100	3.000	3.000
SFA	(GM)	2.000	1.000	2.000	1.000	1.000
PUFA	(GM)	7.000	2.000	7.000	1.000	1.000
CHOLE	(GM)	0.006	0.005	0.006	0.004	0.005
CHO-T	(GM)	52.300	50.500	42.300	55.400	47.700
SUCR	(GM)	1.000	1.000	1.000	1.000	1.000
CHO-F	(GM)	0.200	0.200	0.100	0.200	1.600
THIA	(MG)	0.270	0.250	0.170	0.280	0.260
RIBO	(MG)	0.250	0.210	0.230	0.220	0.120
NIACIN	(MG)	2.000	2.400	1.400	2.500	2.800
VIT-B6	(MG)	40.000	40.000	50.000	50.000	180.000
FOLIC	(UG)	8.000	17.000	8.000	9.000	38.000
VIT-B12	(UG)	0.0	0.0	0.160	0.0	0.0
VIT-C	(MG)	0.0	0.0	0.0	0.0	0.0
PANTO	(UG)	400.000	400.000	500.000	400.000	800.000
BIOTIN	(MG)	1.000	1.000	1.000	1.000	2.000
VIT-A	(IU)	0.0	0.0	100.000	0.0	0.0
VIT-D	(IU)	0.0	15.000	8.000	0.0	8.000
VIT-E	(MG)	0.200	0.100	0.200	0.100	0.400
CA	(MG)	68.000	84.000	104.000	43.000	99.000
P	(MG)	232.000	97.000	151.000	85.000	228.000
MG	(MG)	24.000	26.000	24.000	22.000	45.000
FE	(MG)	2.300	2.500	1.600	2.200	2.300
I	(MG)	9.000	9.000	9.000	9.000	11.000
ZN	(MG)	1.200	1.300	1.200	1.400	2.800
NA	(MG)	973.000	507.000	441.000	580.000	527.000
K	(MG)	116.000	105.000	125.000	90.000	273.000
CU	(MG)	0.310	0.230	0.220	0.230	0.220

ITEM CLUSTER		36	37	38	39	40
ATTRIBUTE GROUP		11	11	11	11	11
NUTRIENTS:						
KCAL		384.000	433.000	386.000	568.000	354.000
PROT	(GM)	8.000	9.000	12.700	5.300	10.200
TRY	(MG)	100.000	110.000	80.000	60.000	120.000
THR	(MG)	230.000	260.000	510.000	210.000	340.000
ISO	(MG)	370.000	420.000	590.000	230.000	470.000
LEU	(MG)	620.000	690.000	1670.000	270.000	840.000
LYS	(MG)	180.000	210.000	370.000	280.000	340.000
MET	(MG)	100.000	120.000	240.000	70.000	120.000
CYS	(MG)	160.000	180.000	130.000	50.000	180.000
PHE	(MG)	440.000	490.000	1000.000	250.000	500.000
TYR	(MG)	270.000	310.000	620.000	100.000	300.000
VAL	(MG)	340.000	390.000	660.000	290.000	540.000
HIS	(MG)	160.000	180.000	330.000	80.000	220.000
FAT-T	(GM)	9.400	12.000	5.000	39.800	1.600
SFA	(GM)	2.000	3.000	1.000	10.000	0.0
PUFA	(GM)	7.000	8.000	4.000	28.000	1.000
CHOLE	(GM)	0.0	0.0	0.0	0.0	0.0
CHO-T	(GM)	73.300	71.500	76.700	50.000	80.500
SUCR	(GM)	24.100	0.200	1.000	0.200	20.100
CHO-F	(GM)	1.100	0.400	2.200	1.600	1.600
THIA	(MG)	0.040	0.010	0.420	0.210	0.640
RIBO	(MG)	0.210	0.040	0.120	0.070	0.140
NIACIN	(MG)	1.500	1.000	2.200	4.800	4.900
VIT-B6	(MG)	70.000	70.000	200.000	180.000	290.000
FOLIC	(UG)	24.000	24.000	0.0	9.000	18.000
VIT-B12	(UG)	0.0	0.0	0.0	0.0	0.0
VIT-C	(MG)	0.0	0.0	0.0	16.000	0.0
PANTO	(UG)	500.000	500.000	400.000	500.000	500.000
BIOTIN	(MG)	1.000	1.000	1.000	7.000	1.000
VIT-A	(IU)	0.0	0.0	0.0	0.0	0.0
VIT-D	(IU)	0.0	0.0	0.0	0.0	0.0
VIT-E	(MG)	0.100	0.100	4.400	4.300	0.500
CA	(MG)	40.000	21.000	11.000	40.000	41.000
P	(MG)	149.000	90.000	281.000	139.000	309.000
MG	(MG)	36.000	25.000	173.000	43.000	96.000
FE	(MG)	1.500	1.200	2.700	1.800	4.400
I	(MG)	2.000	2.000	14.000	13.000	14.000
ZN	(MG)	0.800	0.700	2.000	2.500	2.400
NA	(MG)	670.000	1100.000	3.000	1000.000	1032.000
K	(MG)	384.000	120.000	200.000	1130.000	120.000
CU	(MG)	0.180	0.170	0.310	0.220	0.450

ITEM CLUSTER		41	42	43	44	45
ATTRIBUTE GROUP		12	12	12	12	12
NUTRIENTS:						
KCAL		377.000	286.000	261.000	216.000	266.000
PROT	(GM)	24.200	24.200	28.600	25.300	25.800
TRY	(MG)	300.000	250.000	350.000	290.000	330.000
THR	(MG)	1100.000	960.000	1300.000	1100.000	1180.000
ISO	(MG)	1300.000	1130.000	1500.000	1300.000	1330.000
LEU	(MG)	2100.000	1770.000	2500.000	2100.000	1990.000
LYS	(MG)	2200.000	1890.000	2600.000	2200.000	2060.000
MET	(MG)	640.000	540.000	760.000	630.000	630.000
CYS	(MG)	320.000	270.000	380.000	320.000	340.000
PHE	(MG)	990.000	1000.000	1170.000	1040.000	1000.000
TYR	(MG)	900.000	740.000	1060.000	900.000	890.000
VAL	(MG)	1500.000	1190.000	1800.000	1400.000	1260.000
HIS	(MG)	890.000	750.000	1050.000	870.000	720.000
FAT-T	(GM)	30.300	20.300	15.400	12.000	17.300
SFA	(GM)	14.000	10.000	7.000	6.000	10.000
PUFA	(GM)	14.000	9.000	7.000	5.000	5.000
CHOLE	(GM)	0.070	0.070	0.070	0.070	0.070
CHO-T	(GM)	0.0	0.0	0.0	0.0	0.0
SUCR	(GM)	0.0	0.0	0.0	0.0	0.0
CHO-F	(GM)	0.0	0.0	0.0	0.0	0.0
THIA	(MG)	0.040	0.090	0.080	0.020	0.150
RIBO	(MG)	0.190	0.210	0.220	0.240	0.270
NIACIN	(MG)	3.800	5.400	5.600	3.400	5.600
VIT-B6	(MG)	350.000	460.000	410.000	100.000	320.000
FOLIC	(UG)	3.000	5.000	4.000	3.000	3.000
VIT-B12	(UG)	1.800	0.900	2.650	1.840	3.100
VIT-C	(MG)	0.0	0.0	0.0	0.0	0.0
PANTO	(UG)	400.000	400.000	500.000	600.000	600.000
BIOTIN	(MG)	3.000	3.000	3.000	3.000	6.000
VIT-A	(IU)	60.000	40.000	30.000	20.000	0.0
VIT-D	(IU)	0.0	0.0	0.0	0.0	0.0
VIT-E	(MG)	0.200	0.400	0.200	0.100	0.200
CA	(MG)	10.000	11.000	12.000	20.000	11.000
P	(MG)	121.000	194.000	250.000	106.000	212.000
MG	(MG)	23.000	21.000	28.000	27.000	22.000
FE	(MG)	3.100	3.200	3.500	4.300	1.800
I	(MG)	6.000	6.000	6.000	6.000	3.000
ZN	(MG)	2.500	4.300	3.000	3.100	5.400
NA	(MG)	60.000	47.000	60.000	1010.000	70.000
K	(MG)	370.000	450.000	370.000	87.000	290.000
CU	(MG)	0.080	0.080	0.080	0.210	0.240

ITEM CLUSTER		46	47	48	49	50
ATTRIBUTE GROUP		12	12	12	13	13
NUTRIENTS:						
KCAL		373.000	193.000	611.000	198.000	161.000
PROT	(GM)	22.600	18.300	30.400	21.700	15.300
TRY	(MG)	300.000	180.000	320.000	250.000	230.000
THR	(MG)	1050.000	760.000	1000.000	890.000	790.000
ISO	(MG)	1160.000	920.000	1300.000	800.000	1000.000
LEU	(MG)	1650.000	1430.000	2400.000	1100.000	1340.000
LYS	(MG)	1850.000	1550.000	2000.000	1300.000	1630.000
MET	(MG)	570.000	450.000	470.000	400.000	480.000
CYS	(MG)	270.000	300.000	360.000	210.000	250.000
PHE	(MG)	890.000	700.000	1400.000	600.000	490.000
TYR	(MG)	810.000	720.000	780.000	540.000	650.000
VAL	(MG)	1190.000	960.000	1400.000	750.000	920.000
HIS	(MG)	780.000	600.000	820.000	440.000	530.000
FAT-T	(GM)	30.600	12.300	52.000	11.700	9.300
SFA	(GM)	12.000	4.000	17.000	4.000	3.000
PUFA	(GM)	15.000	6.000	30.000	6.000	6.000
CHOLE	(GM)	0.070	0.070	0.080	0.070	0.040
CHO-T	(GM)	0.0	0.900	3.200	0.0	3.200
SUCR	(GM)	0.0	0.0	3.200	0.0	0.0
CHO-F	(GM)	0.0	0.0	0.0	0.0	0.0
THIA	(MG)	0.500	0.530	0.510	0.040	0.020
RIBO	(MG)	0.230	0.190	0.340	0.120	0.070
NIACIN	(MG)	4.900	3.800	5.200	4.400	2.400
VIT-B6	(MG)	320.000	360.000	100.000	300.000	250.000
FOLIC	(UG)	3.000	3.000	2.000	2.000	4.000
VIT-B12	(UG)	0.500	0.500	0.700	0.790	0.260
VIT-C	(MG)	0.0	0.0	0.0	4.000	0.0
PANTO	(UG)	500.000	400.000	1300.000	900.000	900.000
BIOTIN	(MG)	5.000	5.000	8.000	11.000	6.000
VIT-A	(IU)	0.0	0.0	0.0	230.000	70.000
VIT-D	(IU)	0.0	0.0	0.0	0.0	0.0
VIT-E	(MG)	0.200	0.200	0.300	0.100	0.200
CA	(MG)	10.000	11.000	14.000	21.000	6.000
P	(MG)	232.000	156.000	224.000	247.000	113.000
MG	(MG)	23.000	15.000	25.000	18.000	11.000
FE	(MG)	2.900	2.700	3.300	1.500	0.900
I	(MG)	10.000	8.000	27.000	5.000	6.000
ZN	(MG)	2.700	1.900	5.100	4.900	2.400
NA	(MG)	65.000	1100.000	1021.000	400.000	154.000
K	(MG)	390.000	340.000	236.000	138.000	140.000
CU	(MG)	0.090	0.440	0.520	0.230	0.180

ITEM CLUSTER		51	52	53	54	55
ATTRIBUTE GROUP		13	13	14	14	14
NUTRIENTS:						
KCAL		250.000	263.000	98.000	176.000	165.000
PROT	(GM)	30.600	27.000	15.800	16.600	19.600
TRY	(MG)	370.000	330.000	160.000	170.000	200.000
THR	(MG)	1290.000	1140.000	680.000	720.000	840.000
ISO	(MG)	1600.000	1420.000	800.000	840.000	1000.000
LEU	(MG)	2200.000	2050.000	1200.000	1250.000	1490.000
LYS	(MG)	2700.000	2450.000	840.000	1460.000	1730.000
MET	(MG)	800.000	750.000	460.000	480.000	570.000
CYS	(MG)	410.000	370.000	210.000	220.000	260.000
PHE	(MG)	1200.000	1080.000	580.000	620.000	730.000
TYR	(MG)	1080.000	1080.000	430.000	450.000	530.000
VAL	(MG)	1500.000	1320.000	480.000	880.000	1040.000
HIS	(MG)	880.000	730.000	30.000	760.000	900.000
FAT-T	(GM)	11.900	16.400	2.500	8.900	6.400
SFA	(GM)	3.000	4.000	1.000	2.000	2.000
PUFA	(GM)	8.000	10.000	1.000	6.000	4.000
CHOLE	(GM)	0.070	0.075	0.080	0.070	0.060
CHO-T	(GM)	2.800	0.0	1.900	6.500	5.800
SUCR	(GM)	0.0	0.0	0.0	0.0	0.0
CHO-F	(GM)	0.0	0.0	0.0	0.0	0.0
THIA	(MG)	0.060	0.110	0.010	0.040	0.040
RIBO	(MG)	0.360	0.200	0.110	0.070	0.070
NIACIN	(MG)	9.200	11.400	1.100	1.600	3.200
VIT-B6	(MG)	400.000	400.000	80.000	50.000	140.000
FOLIC	(UG)	6.000	10.000	3.000	16.000	16.000
VIT-B12	(UG)	0.420	0.420	19.100	1.000	1.000
VIT-C	(MG)	0.0	2.000	11.000	2.000	2.000
PANTO	(UG)	900.000	900.000	300.000	300.000	300.000
BIOTIN	(MG)	11.000	11.000	20.000	3.000	3.000
VIT-A	(IU)	170.000	170.000	110.000	0.0	320.000
VIT-D	(IU)	0.0	0.0	3.000	0.0	0.0
VIT-E	(MG)	0.200	0.300	0.300	0.600	0.600
CA	(MG)	12.000	11.000	55.000	11.000	40.000
P	(MG)	243.000	300.000	184.000	167.000	247.000
MG	(MG)	19.000	25.000	113.000	18.000	36.000
FE	(MG)	1.800	2.100	4.100	0.400	1.200
I	(MG)	7.000	6.000	90.000	34.000	62.000
ZN	(MG)	4.600	2.800	1.600	0.300	0.300
NA	(MG)	88.000	93.000	1010.000	180.000	177.000
K	(MG)	428.000	443.000	140.000	390.000	348.000
CU	(MG)	0.330	0.180	0.0	0.140	0.150

ITEM CLUSTER		56	57	58	59	60
ATTRIBUTE GROUP		14	14	14	14	14
NUTRIENTS:						
KCAL		171.000	76.000	239.000	182.000	210.000
PROT	(GM)	25.200	8.500	8.600	27.000	19.600
TRY	(MG)	250.000	90.000	90.000	270.000	200.000
THR	(MG)	1080.000	370.000	370.000	1160.000	840.000
ISO	(MG)	1290.000	430.000	440.000	1350.000	980.000
LEU	(MG)	1920.000	640.000	650.000	2030.000	1470.000
LYS	(MG)	2220.000	280.000	280.000	2350.000	1710.000
MET	(MG)	730.000	250.000	250.000	780.000	570.000
CYS	(MG)	340.000	110.000	120.000	380.000	280.000
PHE	(MG)	940.000	320.000	320.000	1000.000	730.000
TYR	(MG)	690.000	230.000	230.000	730.000	530.000
VAL	(MG)	1330.000	450.000	460.000	1430.000	1040.000
HIS	(MG)	1160.000	960.000	960.000	700.000	510.000
FAT-T	(GM)	7.000	2.200	13.900	7.400	14.000
SFA	(GM)	3.000	1.000	4.000	2.000	4.000
PUFA	(GM)	3.000	1.000	8.000	3.000	4.000
CHOLE	(GM)	0.060	0.230	0.230	0.060	0.060
CHO-T	(GM)	0.0	4.900	18.600	0.0	0.0
SUCR	(GM)	0.0	0.0	0.0	0.0	0.0
CHO-F	(GM)	0.0	0.100	0.0	0.0	0.0
THIA	(MG)	0.050	0.020	0.170	0.160	0.030
RIBO	(MG)	0.070	0.200	0.290	0.060	0.140
NIACIN	(MG)	8.300	0.800	3.200	9.800	7.300
VIT-B6	(MG)	340.000	40.000	40.000	300.000	300.000
FOLIC	(UG)	16.000	3.000	3.000	7.000	7.000
VIT-B12	(UG)	1.000	18.000	18.000	1.000	6.900
VIT-C	(MG)	4.000	26.000	39.000	5.000	9.000
PANTO	(UG)	300.000	200.000	200.000	500.000	600.000
BIOTIN	(MG)	8.000	9.000	9.000	12.000	12.000
VIT-A	(IU)	680.000	260.000	440.000	160.000	230.000
VIT-D	(IU)	0.0	10.000	5.000	400.000	370.000
VIT-E	(MG)	0.600	0.300	0.600	1.400	0.500
CA	(MG)	16.000	28.000	152.000	80.000	154.000
P	(MG)	248.000	124.000	241.000	414.000	289.000
MG	(MG)	23.000	17.000	17.000	41.000	27.000
FE	(MG)	0.800	5.600	8.100	1.200	0.900
I	(MG)	46.000	48.000	69.000	37.000	51.000
ZN	(MG)	1.000	52.000	52.000	1.700	0.700
NA	(MG)	134.000	62.000	206.000	116.000	407.000
K	(MG)	525.000	70.000	203.000	443.000	366.000
CU	(MG)	0.190	3.430	4.270	0.800	0.290

ITEM CLUSTER		61	62	63	64	65
ATTRIBUTE GROUP		14	14	14	14	14
NUTRIENTS:						
KCAL		176.000	203.000	94.000	223.000	197.000
PROT	(GM)	21.600	24.000	21.000	12.300	28.800
TRY	(MG)	220.000	210.000	240.000	150.000	290.000
THR	(MG)	930.000	920.000	1040.000	560.000	1240.000
ISO	(MG)	1040.000	1070.000	1230.000	690.000	1470.000
LEU	(MG)	1620.000	1590.000	1840.000	1050.000	2160.000
LYS	(MG)	1890.000	1850.000	2130.000	1030.000	2530.000
MET	(MG)	630.000	610.000	700.000	360.000	840.000
CYS	(MG)	310.000	280.000	320.000	180.000	390.000
PHE	(MG)	800.000	880.000	850.000	460.000	1000.000
TYR	(MG)	580.000	570.000	650.000	360.000	780.000
VAL	(MG)	1150.000	1120.000	1280.000	450.000	1530.000
HIS	(MG)	560.000	990.000	530.000	270.000	1550.000
FAT-T	(GM)	9.300	11.100	0.800	11.000	8.200
SFA	(GM)	3.000	5.000	0.0	7.000	3.000
PUFA	(GM)	3.000	5.000	0.0	0.0	4.000
CHOLE	(GM)	0.060	0.070	0.140	0.140	0.060
CHO-T	(GM)	0.0	0.0	0.500	18.600	0.0
SUCR	(GM)	0.0	0.0	0.0	0.0	0.0
CHO-F	(GM)	0.0	0.0	0.100	0.100	0.0
THIA	(MG)	0.210	0.030	0.020	0.030	0.050
RIBO	(MG)	0.080	0.200	0.030	0.030	0.120
NIACIN	(MG)	12.700	5.400	3.300	2.000	11.900
VIT-B6	(MG)	700.000	180.000	50.000	60.000	430.000
FOLIC	(UG)	7.000	32.000	2.000	2.000	1.000
VIT-B12	(UG)	7.000	10.000	0.690	0.720	2.200
VIT-C	(MG)	5.000	0.0	11.000	7.000	10.000
PANTO	(UG)	700.000	900.000	200.000	300.000	300.000
BIOTIN	(MG)	12.000	24.000	10.000	10.000	3.000
VIT-A	(IU)	190.000	220.000	40.000	30.000	80.000
VIT-D	(IU)	400.000	500.000	150.000	150.000	250.000
VIT-E	(MG)	1.400	0.600	0.500	0.600	0.500
CA	(MG)	14.000	437.000	78.000	38.000	8.000
P	(MG)	245.000	499.000	208.000	111.000	234.000
MG	(MG)	33.000	39.000	42.000	61.000	27.000
FE	(MG)	1.400	2.900	1.700	1.000	1.900
I	(MG)	37.000	37.000	65.000	66.000	16.000
ZN	(MG)	1.300	2.900	1.500	1.000	0.400
NA	(MG)	134.000	823.000	126.000	213.000	662.000
K	(MG)	512.000	590.000	203.000	197.000	249.000
CU	(MG)	1.300	0.040	0.570	0.370	0.120

ITEM CLUSTER		66	67	68	69	70
ATTRIBUTE GROUP		14	15	16	17	17
NUTRIENTS:						
KCAL		133.000	229.000	245.000	304.000	476.000
PROT	(GM)	27.400	26.400	27.500	12.400	18.100
TRY	(MG)	250.000	390.000	370.000	120.000	160.000
THR	(MG)	1060.000	1240.000	1270.000	510.000	720.000
ISO	(MG)	1260.000	1360.000	1430.000	620.000	880.000
LEU	(MG)	1850.000	2400.000	2450.000	970.000	1290.000
LYS	(MG)	2170.000	1950.000	2275.000	1100.000	1460.000
MET	(MG)	720.000	610.000	685.000	300.000	380.000
CYS	(MG)	330.000	320.000	350.000	200.000	230.000
PHE	(MG)	860.000	1300.000	1235.000	460.000	600.000
TYR	(MG)	670.000	980.000	1020.000	480.000	590.000
VAL	(MG)	1310.000	1690.000	1745.000	650.000	920.000
HIS	(MG)	1330.000	1240.000	1145.000	400.000	490.000
FAT-T	(GM)	3.000	10.600	13.000	27.200	44.200
SFA	(GM)	1.000	3.000	5.000	10.000	16.000
PUFA	(GM)	1.000	6.000	7.000	15.000	23.000
CHOLE	(GM)	0.060	0.300	0.190	0.070	0.070
CHO-T	(GM)	0.0	5.300	2.700	1.600	0.0
SUCR	(GM)	0.0	0.0	0.0	1.600	0.0
CHO-F	(GM)	0.0	0.0	0.0	0.0	0.0
THIA	(MG)	0.020	0.260	0.170	0.150	0.790
RIBO	(MG)	0.050	4.190	2.210	0.200	0.340
NIACIN	(MG)	6.600	16.500	11.100	2.500	3.700
VIT-B6	(MG)	900.000	670.000	540.000	110.000	190.000
FOLIC	(UG)	3.000	294.000	149.000	4.000	4.000
VIT-B12	(UG)	3.000	80.000	41.330	1.300	1.400
VIT-C	(MG)	7.000	27.000	14.000	0.0	0.0
PANTO	(UG)	500.000	7100.000	3800.000	400.000	600.000
BIOTIN	(MG)	3.000	96.000	50.000	5.000	5.000
VIT-A	(IU)	50.000	53400.000	26715.000	0.0	0.0
VIT-D	(IU)	250.000	50.000	25.000	0.0	0.0
VIT-E	(MG)	0.200	0.600	0.400	0.100	0.200
CA	(MG)	4.000	11.000	12.000	5.000	7.000
P	(MG)	177.000	476.000	363.000	102.000	162.000
MG	(MG)	29.000	22.000	25.000	9.000	16.000
FE	(MG)	1.300	8.800	6.200	1.500	2.400
I	(MG)	23.000	19.000	13.000	8.000	8.000
ZN	(MG)	0.500	7.000	5.000	1.500	0.600
NA	(MG)	37.000	184.000	122.000	1060.000	958.000
K	(MG)	181.000	380.000	375.000	212.000	269.000
CU	(MG)	0.500	3.700	1.890	0.080	0.150

ITEM CLUSTER		71	72	73	74	75
ATTRIBUTE GROUP		17	18	18	18	18
NUTRIENTS:						
KCAL		307.000	90.000	118.000	108.000	118.000
PROT	(GM)	16.200	5.700	7.800	8.100	9.800
TRY	(MG)	240.000	50.000	70.000	80.000	100.000
THR	(MG)	760.000	250.000	340.000	320.000	370.000
ISO	(MG)	840.000	320.000	450.000	390.000	490.000
LEU	(MG)	1470.000	490.000	670.000	600.000	680.000
LYS	(MG)	1180.000	420.000	580.000	530.000	620.000
MET	(MG)	380.000	60.000	80.000	120.000	140.000
CYS	(MG)	200.000	60.000	80.000	90.000	100.000
PHE	(MG)	820.000	310.000	400.000	450.000	530.000
TYR	(MG)	600.000	220.000	300.000	200.000	380.000
VAL	(MG)	1010.000	340.000	480.000	450.000	540.000
HIS	(MG)	760.000	160.000	220.000	270.000	330.000
FAT-T	(GM)	25.600	0.400	0.600	0.800	5.100
SFA	(GM)	10.000	0.0	0.0	0.0	1.000
PUFA	(GM)	14.000	0.0	0.0	0.0	4.000
CHOLE	(GM)	0.346	0.0	0.0	0.0	0.0
CHO-T	(GM)	1.800	16.400	21.200	18.100	10.100
SUCR	(GM)	0.0	0.700	0.700	1.300	3.400
CHO-F	(GM)	0.0	0.900	1.500	1.800	1.400
THIA	(MG)	0.200	0.050	0.140	0.300	0.310
RIBO	(MG)	1.300	0.040	0.070	0.110	0.130
NIACIN	(MG)	5.700	0.600	0.700	1.400	1.200
VIT-B6	(MG)	930.000	330.000	140.000	50.000	40.000
FOLIC	(UG)	6.000	6.000	8.000	26.000	38.000
VIT-B12	(UG)	2.360	0.0	0.0	0.0	0.0
VIT-C	(MG)	0.0	0.0	0.0	17.000	17.000
PANTO	(UG)	5900.000	100.000	200.000	300.000	700.000
BIOTIN	(MG)	111.000	4.000	6.000	10.000	30.000
VIT-A	(IU)	6350.000	0.0	0.0	350.000	660.000
VIT-D	(IU)	15.000	0.0	0.0	0.0	0.0
VIT-E	(MG)	0.700	0.100	0.200	0.200	0.700
CA	(MG)	9.000	29.000	50.000	24.000	60.000
P	(MG)	238.000	109.000	148.000	146.000	191.000
MG	(MG)	23.000	27.000	37.000	19.000	194.000
FE	(MG)	5.400	1.800	2.700	2.100	2.500
I	(MG)	23.000	2.000	3.000	7.000	4.000
ZN	(MG)	7.500	1.100	1.500	0.800	1.100
NA	(MG)	291.000	236.000	7.000	1.000	2.000
K	(MG)	232.000	264.000	416.000	379.000	487.000
CU	(MG)	3.050	0.100	0.240	0.280	0.810

ITEM CLUSTER		76	77	78	79	80
ATTRIBUTE GROUP		19	19	19	19	19
NUTRIENTS:						
KCAL		598.000	561.000	346.000	581.000	568.000
PROT	(GM)	18.600	17.200	3.500	27.800	26.300
TRY	(MG)	180.000	430.000	32.000	360.000	340.000
THR	(MG)	610.000	690.000	126.000	870.000	820.000
ISO	(MG)	870.000	1140.000	175.000	1300.000	1250.000
LEU	(MG)	1450.000	1410.000	260.000	2000.000	1850.000
LYS	(MG)	580.000	740.000	148.000	1100.000	1090.000
MET	(MG)	260.000	330.000	69.000	280.000	270.000
CYS	(MG)	380.000	480.000	60.000	480.000	450.000
PHE	(MG)	1100.000	950.000	170.000	1600.000	1500.000
TYR	(MG)	620.000	660.000	106.000	1200.000	1090.000
VAL	(MG)	1120.000	1480.000	205.000	1600.000	1520.000
HIS	(MG)	520.000	390.000	670.000	780.000	740.000
FAT-T	(GM)	54.200	45.700	35.300	49.400	48.400
SFA	(GM)	4.000	8.000	30.000	9.000	10.000
PUFA	(GM)	47.000	35.000	2.000	39.000	34.000
CHOLE	(GM)	0.0	0.0	0.0	0.0	0.0
CHO-T	(GM)	19.500	29.300	9.400	17.200	17.600
SUCR	(GM)	2.300	3.000	4.700	4.500	4.500
CHO-F	(GM)	2.600	1.400	4.000	1.900	1.900
THIA	(MG)	0.240	0.430	0.050	0.130	0.990
RIBO	(MG)	0.920	0.250	0.020	0.130	0.130
NIACIN	(MG)	3.500	1.800	0.500	15.700	15.800
VIT-B6	(MG)	100.000	400.000	40.000	330.000	400.000
FOLIC	(UG)	45.000	25.000	27.000	13.000	25.000
VIT-B12	(UG)	0.0	0.0	0.0	0.0	0.0
VIT-C	(MG)	0.0	0.0	3.000	0.0	0.0
PANTO	(UG)	500.000	1300.000	200.000	1700.000	2800.000
BIOTIN	(MG)	8.000	30.000	6.000	39.000	34.000
VIT-A	(IU)	0.0	100.000	0.0	0.0	0.0
VIT-D	(IU)	0.0	0.0	0.0	0.0	0.0
VIT-E	(MG)	15.000	5.100	1.000	6.700	6.500
CA	(MG)	234.000	38.000	13.000	63.000	59.000
P	(MG)	504.000	373.000	95.000	407.000	409.000
MG	(MG)	269.000	267.000	44.000	174.000	168.000
FE	(MG)	4.700	3.800	1.700	2.000	2.000
I	(MG)	2.000	3.000	2.000	12.000	11.000
ZN	(MG)	1.500	1.000	3.000	2.200	2.100
NA	(MG)	4.000	15.000	23.000	607.000	5.000
K	(MG)	773.000	464.000	256.000	670.000	674.000
CU	(MG)	0.680	0.760	0.390	0.570	0.690

ITEM CLUSTER		81	82	83	84	85
ATTRIBUTE GROUP		19	20	20	20	20
NUTRIENTS:						
KCAL		651.000	93.000	274.000	94.000	141.000
PROT	(GM)	14.800	2.600	4.300	2.100	2.100
TRY	(MG)	170.000	30.000	40.000	20.000	40.000
THR	(MG)	580.000	100.000	170.000	90.000	100.000
ISO	(MG)	760.000	120.000	180.000	90.000	100.000
LEU	(MG)	1220.000	130.000	210.000	110.000	120.000
LYS	(MG)	490.000	140.000	220.000	110.000	100.000
MET	(MG)	300.000	30.000	50.000	30.000	40.000
CYS	(MG)	320.000	30.000	40.000	20.000	30.000
PHE	(MG)	760.000	120.000	190.000	90.000	120.000
TYR	(MG)	580.000	50.000	80.000	40.000	100.000
VAL	(MG)	950.000	140.000	200.000	110.000	160.000
HIS	(MG)	400.000	40.000	60.000	30.000	40.000
FAT-T	(GM)	64.000	0.100	13.200	4.300	0.500
SFA	(GM)	4.000	0.0	3.000	2.000	0.0
PUFA	(GM)	50.000	0.0	10.000	1.000	0.0
CHOLE	(GM)	0.0	0.0	0.020	0.015	0.0
CHO-T	(GM)	15.800	21.100	36.000	12.300	32.500
SUCR	(GM)	3.000	0.100	0.200	0.100	7.200
CHO-F	(GM)	2.100	0.600	1.000	0.400	0.900
THIA	(MG)	0.330	0.100	0.130	0.080	0.090
RIBO	(MG)	0.130	0.040	0.080	0.050	0.070
NIACIN	(MG)	0.900	1.700	3.100	1.000	0.700
VIT-B6	(MG)	730.000	200.000	180.000	90.000	170.000
FOLIC	(UG)	58.000	12.000	9.000	12.000	19.000
VIT-B12	(UG)	0.0	0.0	0.0	0.0	0.0
VIT-C	(MG)	2.000	20.000	21.000	9.000	22.000
PANTO	(UG)	900.000	400.000	500.000	200.000	700.000
BIOTIN	(MG)	37.000	2.000	1.000	2.000	2.000
VIT-A	(IU)	30.000	0.0	0.0	170.000	8100.000
VIT-D	(IU)	0.0	0.0	0.0	0.0	0.0
VIT-E	(MG)	22.000	0.0	0.300	0.200	2.000
CA	(MG)	99.000	9.000	15.000	24.000	40.000
P	(MG)	380.000	65.000	111.000	48.000	58.000
MG	(MG)	134.000	22.000	17.000	14.000	12.000
FE	(MG)	3.100	0.700	1.300	0.400	0.900
I	(MG)	3.000	4.000	11.000	3.000	3.000
ZN	(MG)	2.800	0.200	0.200	0.100	0.700
NA	(MG)	2.000	4.000	6.000	331.000	12.000
K	(MG)	450.000	503.000	853.000	250.000	300.000
CU	(MG)	0.900	0.150	0.270	0.100	0.170

ITEM CLUSTER		86	87	88	89	90
ATTRIBUTE GROUP		20	20	21	21	21
NUTRIENTS:						
KCAL		114.000	93.000	167.000	25.000	24.000
PROT	(GM)	1.000	2.600	2.100	1.600	1.400
TRY	(MG)	20.000	30.000	14.000	20.000	20.000
THR	(MG)	50.000	100.000	1.000	60.000	50.000
ISO	(MG)	50.000	120.000	1.000	70.000	70.000
LEU	(MG)	60.000	130.000	1.000	90.000	80.000
LYS	(MG)	50.000	140.000	74.000	80.000	80.000
MET	(MG)	20.000	30.000	12.000	20.000	20.000
CYS	(MG)	20.000	30.000	1.000	20.000	10.000
PHE	(MG)	60.000	120.000	1.000	60.000	40.000
TYR	(MG)	50.000	50.000	1.000	30.000	30.000
VAL	(MG)	80.000	140.000	1.000	80.000	70.000
HIS	(MG)	20.000	40.000	1.000	30.000	30.000
FAT-T	(GM)	0.200	0.100	16.400	0.200	0.200
SFA	(GM)	0.0	0.0	3.000	0.0	0.0
PUFA	(GM)	0.0	0.0	9.000	0.0	0.0
CHOLE	(GM)	0.0	0.0	0.0	0.0	0.0
CHO-T	(GM)	27.500	21.100	6.300	5.400	5.200
SUCR	(GM)	14.900	0.100	1.600	0.400	0.400
CHO-F	(GM)	0.600	0.600	1.600	1.000	1.000
THIA	(MG)	0.030	0.100	0.110	0.070	0.030
RIBO	(MG)	0.030	0.040	0.200	0.090	0.050
NIACIN	(MG)	0.600	1.700	1.600	0.500	0.300
VIT-B6	(MG)	70.000	200.000	420.000	60.000	40.000
FOLIC	(UG)	19.000	12.000	30.000	5.000	12.000
VIT-B12	(UG)	0.0	0.0	0.0	0.0	0.0
VIT-C	(MG)	8.000	20.000	14.000	12.000	4.000
PANTO	(UG)	400.000	400.000	1100.000	200.000	100.000
BIOTIN	(MG)	2.000	2.000	6.000	1.000	1.000
VIT-A	(IU)	5000.000	0.0	290.000	540.000	470.000
VIT-D	(IU)	0.0	0.0	0.0	0.0	0.0
VIT-E	(MG)	0.200	0.0	1.500	0.800	0.0
CA	(MG)	13.000	9.000	10.000	50.000	45.000
P	(MG)	29.000	65.000	42.000	37.000	25.000
MG	(MG)	18.000	22.000	37.000	22.000	14.000
FE	(MG)	0.700	0.700	0.600	0.600	1.500
I	(MG)	3.000	4.000	2.000	3.000	1.000
ZN	(MG)	0.500	0.200	2.400	0.300	0.300
NA	(MG)	48.000	4.000	4.000	4.000	236.000
K	(MG)	120.000	503.000	604.000	151.000	95.000
CU	(MG)	0.060	0.150	0.390	0.090	0.090

ITEM CLUSTER		91	92	93	94	95
ATTRIBUTE GROUP		21	21	21	21	21
NUTRIENTS:						
KCAL		26.000	24.000	20.000	33.000	13.000
PROT	(GM)	3.100	1.300	1.100	3.600	0.900
TRY	(MG)	30.000	10.000	10.000	50.000	10.000
THR	(MG)	120.000	40.000	30.000	160.000	40.000
ISO	(MG)	120.000	50.000	40.000	150.000	40.000
LEU	(MG)	150.000	50.000	40.000	290.000	70.000
LYS	(MG)	140.000	60.000	50.000	140.000	50.000
MET	(MG)	50.000	10.000	10.000	40.000	0.0
CYS	(MG)	50.000	30.000	20.000	60.000	10.000
PHE	(MG)	100.000	70.000	60.000	120.000	40.000
TYR	(MG)	110.000	30.000	20.000	140.000	30.000
VAL	(MG)	160.000	40.000	30.000	210.000	50.000
HIS	(MG)	180.000	20.000	20.000	80.000	20.000
FAT-T	(GM)	0.300	0.200	0.200	0.700	0.100
SFA	(GM)	0.0	0.0	0.0	0.0	0.0
PUFA	(GM)	0.0	0.0	0.0	0.0	0.0
CHOLE	(GM)	0.0	0.0	0.0	0.0	0.0
CHO-T	(GM)	4.500	5.400	4.300	5.100	2.900
SUCR	(GM)	0.200	0.300	0.200	0.200	0.200
CHO-F	(GM)	1.500	0.800	0.800	1.000	0.500
THIA	(MG)	0.090	0.050	0.040	0.110	0.060
RIBO	(MG)	0.200	0.050	0.040	0.200	0.060
NIACIN	(MG)	0.800	0.300	0.300	1.200	0.300
VIT-B6	(MG)	170.000	160.000	130.000	200.000	60.000
FOLIC	(UG)	22.000	55.000	11.000	24.000	200.000
VIT-B12	(UG)	0.0	0.0	0.0	0.0	0.0
VIT-C	(MG)	90.000	47.000	33.000	76.000	6.000
PANTO	(UG)	500.000	200.000	200.000	500.000	200.000
BIOTIN	(MG)	1.000	2.000	1.000	1.000	3.000
VIT-A	(IU)	2500.000	130.000	130.000	7800.000	330.000
VIT-D	(IU)	0.0	0.0	0.0	0.0	0.0
VIT-E	(MG)	1.900	7.800	7.600	5.900	0.300
CA	(MG)	88.000	49.000	44.000	188.000	20.000
P	(MG)	62.000	29.000	20.000	52.000	22.000
MG	(MG)	21.000	15.000	12.000	42.000	11.000
FE	(MG)	0.800	0.400	0.300	0.800	0.500
I	(MG)	4.000	3.000	2.000	3.000	10.000
ZN	(MG)	0.200	0.300	0.200	0.700	0.100
NA	(MG)	10.000	20.000	14.000	25.000	9.000
K	(MG)	267.000	233.000	163.000	262.000	175.000
CU	(MG)	0.100	0.120	0.040	0.310	0.090

ITEM CLUSTER		96	97	98	99	100
ATTRIBUTE GROUP		21	21	21	21	21
NUTRIENTS:						
KCAL		23.000	88.000	68.000	18.000	24.000
PROT	(GM)	2.200	4.700	5.100	1.000	2.700
TRY	(MG)	40.000	40.000	40.000	10.000	40.000
THR	(MG)	60.000	180.000	80.000	40.000	120.000
ISO	(MG)	70.000	220.000	240.000	40.000	130.000
LEU	(MG)	60.000	300.000	320.000	40.000	210.000
LYS	(MG)	110.000	220.000	240.000	40.000	170.000
MET	(MG)	20.000	40.000	40.000	10.000	50.000
CYS	(MG)	30.000	50.000	60.000	20.000	50.000
PHE	(MG)	70.000	180.000	200.000	50.000	130.000
TYR	(MG)	120.000	110.000	120.000	40.000	90.000
VAL	(MG)	100.000	190.000	210.000	30.000	150.000
HIS	(MG)	40.000	80.000	80.000	10.000	60.000
FAT-T	(GM)	0.400	0.400	0.300	0.200	0.600
SFA	(GM)	0.0	0.0	0.0	0.0	0.0
PUFA	(GM)	0.0	0.0	0.0	0.0	0.0
CHOLE	(GM)	0.0	0.0	0.0	0.0	0.0
CHO-T	(GM)	4.000	16.800	11.800	3.800	3.600
SUCR	(GM)	0.300	6.400	4.500	0.100	0.300
CHO-F	(GM)	0.900	2.300	1.900	1.400	0.900
THIA	(MG)	0.080	0.090	0.270	0.060	0.020
RIBO	(MG)	0.140	0.060	0.090	0.070	0.120
NIACIN	(MG)	0.600	0.800	1.700	0.500	0.300
VIT-B6	(MG)	130.000	50.000	130.000	210.000	70.000
FOLIC	(UG)	8.000	15.000	15.000	2.000	29.000
VIT-B12	(UG)	0.0	0.0	0.0	0.0	0.0
VIT-C	(MG)	48.000	8.000	13.000	96.000	14.000
PANTO	(UG)	200.000	200.000	300.000	200.000	100.000
BIOTIN	(MG)	1.000	2.000	2.000	1.000	2.000
VIT-A	(IU)	5800.000	690.000	600.000	420.000	8000.000
VIT-D	(IU)	0.0	0.0	0.0	0.0	0.0
VIT-E	(MG)	1.700	0.0	0.300	0.500	0.100
CA	(MG)	138.000	26.000	19.000	9.000	118.000
P	(MG)	32.000	76.000	86.000	16.000	26.000
MG	(MG)	17.000	13.000	21.000	12.000	43.000
FE	(MG)	1.800	1.900	1.900	0.500	2.600
I	(MG)	4.000	2.000	3.000	9.000	14.000
ZN	(MG)	0.200	1.400	0.900	0.100	0.500
NA	(MG)	18.000	236.000	115.000	9.000	236.000
K	(MG)	220.000	96.000	135.000	149.000	250.000
CU	(MG)	0.090	0.170	0.210	0.070	0.100

ITEM CLUSTER		101	102	103	104	105
ATTRIBUTE GROUP		21	21	22	22	22
NUTRIENTS:						
KCAL		23.000	26.000	37.000	31.000	42.000
PROT	(GM)	3.000	3.200	1.000	0.900	1.100
TRY	(MG)	50.000	50.000	10.000	10.000	10.000
THR	(MG)	130.000	140.000	20.000	30.000	40.000
ISO	(MG)	140.000	150.000	40.000	30.000	40.000
LEU	(MG)	230.000	250.000	30.000	50.000	60.000
LYS	(MG)	190.000	200.000	50.000	40.000	50.000
MET	(MG)	50.000	50.000	10.000	10.000	10.000
CYS	(MG)	60.000	60.000	10.000	20.000	30.000
PHE	(MG)	140.000	150.000	20.000	30.000	40.000
TYR	(MG)	90.000	100.000	30.000	20.000	20.000
VAL	(MG)	170.000	180.000	30.000	40.000	50.000
HIS	(MG)	60.000	70.000	20.000	10.000	20.000
FAT-T	(GM)	0.300	0.300	0.100	0.200	0.200
SFA	(GM)	0.0	0.0	0.0	0.0	0.0
PUFA	(GM)	0.0	0.0	0.0	0.0	0.0
CHOLE	(GM)	0.0	0.0	0.0	0.0	0.0
CHO-T	(GM)	3.700	4.300	8.800	7.100	9.700
SUCR	(GM)	0.300	0.300	1.300	1.200	1.700
CHO-F	(GM)	0.800	0.600	0.800	1.000	1.000
THIA	(MG)	0.070	0.100	0.010	0.050	0.060
RIBO	(MG)	0.150	0.200	0.030	0.050	0.050
NIACIN	(MG)	0.400	0.600	0.100	0.500	0.600
VIT-B6	(MG)	190.000	280.000	50.000	30.000	150.000
FOLIC	(UG)	29.000	75.000	20.000	3.000	15.000
VIT-B12	(UG)	0.0	0.0	0.0	0.0	0.0
VIT-C	(MG)	19.000	51.000	3.000	6.000	8.000
PANTO	(UG)	100.000	300.000	100.000	300.000	300.000
BIOTIN	(MG)	2.000	7.000	1.000	2.000	3.000
VIT-A	(IU)	7900.000	8100.000	20.000	10500.000	1000.000
VIT-D	(IU)	0.0	0.0	0.0	0.0	0.0
VIT-E	(MG)	1.100	2.900	0.0	0.500	0.500
CA	(MG)	113.000	93.000	19.000	33.000	37.000
P	(MG)	44.000	51.000	18.000	31.000	36.000
MG	(MG)	42.000	57.000	15.000	6.000	18.000
FE	(MG)	2.100	3.100	0.700	0.600	0.700
I	(MG)	3.000	9.000	5.000	2.000	2.000
ZN	(MG)	0.500	0.700	0.400	0.300	0.500
NA	(MG)	52.000	71.000	236.000	33.000	47.000
K	(MG)	333.000	470.000	167.000	222.000	341.000
CU	(MG)	0.800	0.140	0.210	0.090	0.090

ITEM CLUSTER		106	107	108	109	110
ATTRIBUTE GROUP		22	22	22	22	22
NUTRIENTS:						
KCAL		83.000	82.000	84.000	14.000	21.000
PROT	(GM)	3.200	2.100	2.600	0.900	1.000
TRY	(MG)	20.000	10.000	20.000	10.000	10.000
THR	(MG)	130.000	90.000	110.000	20.000	30.000
ISO	(MG)	120.000	80.000	100.000	30.000	30.000
LEU	(MG)	250.000	230.000	290.000	40.000	40.000
LYS	(MG)	120.000	80.000	100.000	30.000	40.000
MET	(MG)	60.000	40.000	50.000	10.000	10.000
CYS	(MG)	50.000	40.000	40.000	10.000	10.000
PHE	(MG)	180.000	120.000	150.000	20.000	20.000
TYR	(MG)	110.000	70.000	90.000	20.000	10.000
VAL	(MG)	200.000	130.000	170.000	30.000	30.000
HIS	(MG)	80.000	50.000	70.000	10.000	20.000
FAT-T	(GM)	1.000	0.600	0.800	0.100	0.200
SFA	(GM)	0.0	0.0	0.0	0.0	0.0
PUFA	(GM)	0.0	0.0	0.0	0.0	0.0
CHOLE	(GM)	0.0	0.0	0.0	0.0	0.0
CHO-T	(GM)	18.800	20.000	19.800	3.100	4.300
SUCR	(GM)	0.300	0.300	0.300	0.700	0.300
CHO-F	(GM)	0.700	0.500	0.800	0.600	0.400
THIA	(MG)	0.110	0.030	0.030	0.050	0.050
RIBO	(MG)	0.100	0.050	0.050	0.080	0.030
NIACIN	(MG)	1.300	1.000	0.900	0.800	0.700
VIT-B6	(MG)	290.000	200.000	200.000	60.000	90.000
FOLIC	(UG)	2.000	2.000	2.000	2.000	26.000
VIT-B12	(UG)	0.0	0.0	0.0	0.0	0.0
VIT-C	(MG)	7.000	5.000	4.000	10.000	17.000
PANTO	(UG)	400.000	300.000	200.000	200.000	200.000
BIOTIN	(MG)	2.000	2.000	2.000	2.000	2.000
VIT-A	(IU)	400.000	330.000	350.000	390.000	900.000
VIT-D	(IU)	0.0	0.0	0.0	0.0	0.0
VIT-E	(MG)	1.200	0.100	0.100	2.400	0.0
CA	(MG)	3.000	3.000	5.000	25.000	6.000
P	(MG)	89.000	56.000	49.000	25.000	19.000
MG	(MG)	31.000	20.000	21.000	15.000	11.000
FE	(MG)	0.600	0.600	0.500	0.400	0.500
I	(MG)	4.000	2.000	2.000	4.000	0.0
ZN	(MG)	0.300	0.300	0.300	0.400	0.100
NA	(MG)	0.0	236.000	236.000	1.000	130.000
K	(MG)	165.000	97.000	97.000	141.000	217.000
CU	(MG)	0.090	0.060	0.060	0.080	0.130

ITEM CLUSTER		111	112	113	114	115
ATTRIBUTE GROUP		22	22	23	23	23
NUTRIENTS:						
KCAL		22.000	23.000	14.000	17.000	29.000
PROT	(GM)	1.100	0.800	0.600	1.900	1.200
TRY	(MG)	10.000	10.000	0.0	10.000	20.000
THR	(MG)	40.000	20.000	20.000	40.000	20.000
ISO	(MG)	30.000	10.000	20.000	420.000	20.000
LEU	(MG)	50.000	40.000	30.000	220.000	30.000
LYS	(MG)	50.000	40.000	30.000	60.000	60.000
MET	(MG)	10.000	10.000	10.000	130.000	10.000
CYS	(MG)	10.000	10.000	10.000	20.000	20.000
PHE	(MG)	30.000	10.000	10.000	20.000	40.000
TYR	(MG)	20.000	20.000	20.000	30.000	40.000
VAL	(MG)	30.000	30.000	20.000	300.000	30.000
HIS	(MG)	20.000	10.000	0.0	20.000	10.000
FAT-T	(GM)	0.200	0.200	0.100	0.100	0.100
SFA	(GM)	0.0	0.0	0.0	0.0	0.0
PUFA	(GM)	0.0	0.0	0.0	0.0	0.0
CHOLE	(GM)	0.0	0.0	0.0	0.0	0.0
CHO-T	(GM)	4.700	4.900	3.200	2.400	6.500
SUCR	(GM)	0.300	0.700	0.100	0.0	2.200
CHO-F	(GM)	0.500	0.900	0.300	0.600	0.600
THIA	(MG)	0.060	0.040	0.030	0.020	0.030
RIBO	(MG)	0.040	0.050	0.040	0.250	0.030
NIACIN	(MG)	0.700	0.300	0.200	2.000	0.200
VIT-B6	(MG)	100.000	70.000	40.000	60.000	100.000
FOLIC	(UG)	18.000	1.000	14.000	8.000	25.000
VIT-B12	(UG)	0.0	0.0	0.0	0.0	0.0
VIT-C	(MG)	23.000	22.000	11.000	2.000	7.000
PANTO	(UG)	300.000	100.000	300.000	1000.000	100.000
BIOTIN	(MG)	4.000	1.000	3.000	7.000	2.000
VIT-A	(IU)	900.000	0.0	0.0	0.0	40.000
VIT-D	(IU)	0.0	0.0	0.0	40.000	0.0
VIT-E	(MG)	0.300	0.0	0.100	0.0	0.200
CA	(MG)	13.000	35.000	17.000	6.000	24.000
P	(MG)	27.000	24.000	18.000	68.000	29.000
MG	(MG)	13.000	14.000	10.000	8.000	8.000
FE	(MG)	0.500	0.400	0.300	0.500	0.400
I	(MG)	2.000	3.000	2.000	0.0	3.000
ZN	(MG)	0.200	0.100	0.100	0.400	0.600
NA	(MG)	3.000	34.000	6.000	400.000	7.000
K	(MG)	244.000	188.000	160.000	197.000	110.000
CU	(MG)	0.110	0.040	0.050	0.260	0.080

ITEM CLUSTER		116	117	118	119	120
ATTRIBUTE GROUP		24	25	25	25	26
NUTRIENTS:						
KCAL		64.000	116.000	146.000	11.000	384.000
PROT	(GM)	3.200	1.400	0.700	0.700	0.0
TRY	(MG)	20.000	10.000	10.000	10.000	0.0
THR	(MG)	80.000	40.000	20.000	20.000	0.0
ISO	(MG)	140.000	40.000	20.000	20.000	0.0
LEU	(MG)	190.000	60.000	30.000	30.000	0.0
LYS	(MG)	150.000	60.000	30.000	30.000	0.0
MET	(MG)	30.000	10.000	10.000	10.000	0.0
CYS	(MG)	50.000	20.000	10.000	10.000	0.0
PHE	(MG)	100.000	30.000	20.000	20.000	0.0
TYR	(MG)	80.000	60.000	30.000	30.000	0.0
VAL	(MG)	150.000	50.000	20.000	20.000	0.0
HIS	(MG)	60.000	0.0	0.0	0.0	0.0
FAT-T	(GM)	0.300	12.700	0.400	0.200	100.000
SFA	(GM)	0.0	2.000	0.0	0.0	23.000
PUFA	(GM)	0.0	10.000	0.0	0.0	72.000
CHOLE	(GM)	0.0	0.0	0.0	0.0	0.0
CHO-T	(GM)	13.400	1.300	36.500	2.200	0.0
SUCR	(GM)	1.600	0.0	33.400	0.0	0.0
CHO-F	(GM)	1.200	1.300	0.500	0.500	0.0
THIA	(MG)	0.120	0.0	0.0	0.0	0.0
RIBO	(MG)	0.070	0.0	0.020	0.020	0.0
NIACIN	(MG)	1.100	0.0	0.0	0.0	0.0
VIT-B6	(MG)	100.000	20.000	10.000	10.000	0.0
FOLIC	(UG)	15.000	13.000	3.000	3.000	0.0
VIT-B12	(UG)	0.0	0.0	0.0	0.0	0.0
VIT-C	(MG)	8.000	2.000	6.000	16.000	0.0
PANTO	(UG)	300.000	0.0	200.000	200.000	0.0
BIOTIN	(MG)	2.000	1.000	1.000	1.000	0.0
VIT-A	(IU)	4950.000	300.000	90.000	100.000	0.0
VIT-D	(IU)	0.0	0.0	0.0	0.0	0.0
VIT-E	(MG)	0.500	0.0	0.0	0.0	2.300
CA	(MG)	25.000	61.000	12.000	26.000	0.0
P	(MG)	63.000	17.000	16.000	21.000	0.0
MG	(MG)	25.000	12.000	1.000	1.000	1.000
FE	(MG)	1.300	1.600	1.200	1.000	0.0
I	(MG)	1.000	17.000	17.000	17.000	24.000
ZN	(MG)	0.600	0.300	0.500	0.500	0.800
NA	(MG)	53.000	2400.000	823.000	1420.000	0.0
K	(MG)	191.000	55.000	200.000	200.000	0.0
CU	(MG)	0.120	0.370	0.210	0.020	0.030

ITEM CLUSTER		121	122	123	124	125
ATTRIBUTE GROUP		26	26	26	26	27
NUTRIENTS:						
KCAL		902.000	884.000	884.000	884.000	716.000
PROT	(GM)	0.0	0.0	0.0	0.0	0.600
TRY	(MG)	0.0	0.0	0.0	0.0	0.0
THR	(MG)	0.0	0.0	0.0	0.0	0.0
ISO	(MG)	0.0	0.0	0.0	0.0	0.0
LEU	(MG)	0.0	0.0	0.0	0.0	0.0
LYS	(MG)	0.0	0.0	0.0	0.0	0.0
MET	(MG)	0.0	0.0	0.0	0.0	0.0
CYS	(MG)	0.0	0.0	0.0	0.0	0.0
PHE	(MG)	0.0	0.0	0.0	0.0	0.0
TYR	(MG)	0.0	0.0	0.0	0.0	0.0
VAL	(MG)	0.0	0.0	0.0	0.0	0.0
HIS	(MG)	0.0	0.0	0.0	0.0	0.0
FAT-T	(GM)	100.000	100.000	100.000	100.000	81.000
SFA	(GM)	38.000	25.000	11.000	15.000	46.000
PUFA	(GM)	56.000	71.000	83.000	72.000	29.000
CHOLE	(GM)	0.090	0.0	0.0	0.0	0.270
CHO-T	(GM)	0.0	0.0	0.0	0.0	0.400
SUCR	(GM)	0.0	0.0	0.0	0.0	0.0
CHO-F	(GM)	0.0	0.0	0.0	0.0	0.0
THIA	(MG)	0.0	0.0	0.0	0.0	0.0
RIBO	(MG)	0.0	0.0	0.0	0.0	0.0
NIACIN	(MG)	0.0	0.0	0.0	0.0	0.0
VIT-B6	(MG)	20.000	0.0	0.0	0.0	0.0
FOLIC	(UG)	0.0	0.0	0.0	0.0	0.0
VIT-B12	(UG)	0.0	0.0	0.0	0.0	0.100
VIT-C	(MG)	0.0	0.0	0.0	0.0	0.0
PANTO	(UG)	0.0	0.0	0.0	0.0	0.0
BIOTIN	(MG)	0.0	0.0	0.0	0.0	10.000
VIT-A	(IU)	0.0	0.0	0.0	0.0	3300.000
VIT-D	(IU)	0.0	0.0	0.0	0.0	40.000
VIT-E	(MG)	1.200	43.600	14.400	12.100	1.900
CA	(MG)	0.0	0.0	0.0	0.0	20.000
P	(MG)	0.0	0.0	0.0	0.0	16.000
MG	(MG)	1.000	1.000	1.000	1.000	2.000
FE	(MG)	0.0	0.0	0.0	0.0	0.0
I	(MG)	3.000	4.000	7.000	4.000	9.000
ZN	(MG)	0.500	0.500	0.500	0.500	0.300
NA	(MG)	0.0	0.0	0.0	0.0	987.000
K	(MG)	0.0	0.0	0.0	0.0	23.000
CU	(MG)	0.020	0.070	0.070	0.070	0.030

ITEM CLUSTER		126	127	128	129	130
ATTRIBUTE GROUP		27	28	28	28	28
NUTRIENTS:						
KCAL		720.000	173.000	228.000	162.000	106.000
PROT	(GM)	0.600	7.900	1.700	3.900	2.000
TRY	(MG)	0.0	110.000	20.000	90.000	20.000
THR	(MG)	0.0	290.000	50.000	230.000	70.000
ISO	(MG)	0.0	510.000	80.000	350.000	60.000
LEU	(MG)	0.0	760.000	130.000	580.000	80.000
LYS	(MG)	0.0	570.000	40.000	260.000	80.000
MET	(MG)	0.0	200.000	20.000	110.000	10.000
CYS	(MG)	0.0	50.000	30.000	120.000	20.000
PHE	(MG)	0.0	410.000	90.000	190.000	50.000
TYR	(MG)	0.0	390.000	60.000	270.000	30.000
VAL	(MG)	0.0	560.000	70.000	350.000	60.000
HIS	(MG)	0.0	260.000	30.000	150.000	30.000
FAT-T	(GM)	81.000	13.000	19.500	12.500	0.400
SFA	(GM)	19.000	7.000	9.000	7.000	0.0
PUFA	(GM)	60.000	5.000	9.000	4.000	0.0
CHOLE	(GM)	0.0	0.070	0.010	0.040	0.0
CHO-T	(GM)	0.400	6.400	11.100	8.800	25.400
SUCR	(GM)	0.0	0.0	0.0	0.0	16.600
CHO-F	(GM)	0.0	0.0	0.0	0.0	0.500
THIA	(MG)	0.0	0.030	0.060	0.040	0.090
RIBO	(MG)	0.0	0.210	0.040	0.170	0.070
NIACIN	(MG)	0.0	0.0	0.0	0.200	1.600
VIT-B6	(MG)	0.0	40.000	50.000	50.000	110.000
FOLIC	(UG)	0.0	9.000	1.000	1.000	27.000
VIT-B12	(UG)	0.0	0.400	0.160	0.160	0.0
VIT-C	(MG)	0.0	1.000	0.0	0.0	15.000
PANTO	(UG)	0.0	200.000	200.000	600.000	200.000
BIOTIN	(MG)	0.0	4.000	0.0	4.000	4.000
VIT-A	(IU)	3300.000	550.000	0.0	460.000	1400.000
VIT-D	(IU)	0.0	1.000	0.0	0.0	0.0
VIT-E	(MG)	12.500	0.500	0.200	0.100	0.200
CA	(MG)	20.000	234.000	0.0	115.000	22.000
P	(MG)	16.000	172.000	11.000	93.000	50.000
MG	(MG)	2.000	17.000	2.000	14.000	21.000
FE	(MG)	0.0	0.300	0.600	0.200	0.800
I	(MG)	7.000	8.000	1.000	7.000	6.000
ZN	(MG)	0.300	0.900	0.500	0.400	1.100
NA	(MG)	987.000	518.000	1000.000	379.000	1042.000
K	(MG)	23.000	106.000	106.000	139.000	363.000
CU	(MG)	0.030	0.070	0.010	0.040	0.510

ITEM CLUSTER		131	132	133	134	135
ATTRIBUTE GROUP		28	29	29	29	29
NUTRIENTS:						
KCAL		21.000	718.000	552.000	435.000	368.000
PROT	(GM)	1.000	1.100	0.200	1.000	21.500
TRY	(MG)	10.000	0.0	0.0	0.0	290.000
THR	(MG)	30.000	0.0	0.0	0.0	810.000
ISO	(MG)	30.000	0.0	0.0	0.0	1480.000
LEU	(MG)	40.000	0.0	0.0	0.0	2140.000
LYS	(MG)	40.000	0.0	0.0	0.0	1550.000
MET	(MG)	10.000	0.0	0.0	0.0	580.000
CYS	(MG)	10.000	0.0	0.0	0.0	120.000
PHE	(MG)	20.000	0.0	0.0	0.0	1200.000
TYR	(MG)	10.000	0.0	0.0	0.0	1030.000
VAL	(MG)	30.000	0.0	0.0	0.0	1580.000
HIS	(MG)	20.000	0.0	0.0	0.0	700.000
FAT-T	(GM)	0.200	79.900	60.000	42.300	30.500
SFA	(GM)	0.0	14.000	10.000	8.000	17.000
PUFA	(GM)	0.0	57.000	44.000	30.000	11.000
CHOLE	(GM)	0.0	0.050	0.0	0.050	0.150
CHO-T	(GM)	4.300	2.200	6.900	14.400	2.000
SUCR	(GM)	0.300	0.0	0.0	10.000	0.0
CHO-F	(GM)	0.400	0.0	0.0	0.100	0.0
THIA	(MG)	0.050	0.020	0.0	0.010	0.030
RIBO	(MG)	0.030	0.040	0.0	0.030	0.610
NIACIN	(MG)	0.700	0.0	0.0	0.0	1.200
VIT-B6	(MG)	90.000	0.0	0.0	0.0	170.000
FOLIC	(UG)	26.000	0.0	0.0	0.0	11.000
VIT-B12	(UG)	0.0	0.0	0.0	0.0	1.400
VIT-C	(MG)	17.000	3.000	0.0	3.000	0.0
PANTO	(UG)	200.000	100.000	0.0	100.000	1800.000
BIOTIN	(MG)	2.000	3.000	0.0	3.000	3.000
VIT-A	(IU)	900.000	280.000	0.0	220.000	1240.000
VIT-D	(IU)	0.0	8.000	0.0	8.000	30.000
VIT-E	(MG)	0.0	11.900	9.100	5.300	0.800
CA	(MG)	6.000	18.000	10.000	14.000	315.000
P	(MG)	19.000	28.000	4.000	26.000	339.000
MG	(MG)	11.000	2.000	7.000	2.000	20.000
FE	(MG)	0.500	0.500	0.200	0.200	0.500
I	(MG)	0.0	27.000	2.000	27.000	11.000
ZN	(MG)	0.100	0.500	0.400	0.500	2.200
NA	(MG)	130.000	597.000	2092.000	586.000	666.000
K	(MG)	217.000	34.000	15.000	9.000	78.000
CU	(MG)	0.130	0.240	0.040	0.240	0.160

ITEM CLUSTER		136	137	138	139	140
ATTRIBUTE GROUP		30	30	30	31	31
NUTRIENTS:						
KCAL		65.000	36.000	59.000	138.000	211.000
PROT	(GM)	3.500	3.600	4.200	3.300	3.000
TRY	(MG)	50.000	50.000	60.000	45.000	40.000
THR	(MG)	160.000	160.000	190.000	150.000	140.000
ISO	(MG)	230.000	190.000	270.000	210.000	190.000
LEU	(MG)	350.000	360.000	420.000	325.000	300.000
LYS	(MG)	280.000	280.000	330.000	255.000	230.000
MET	(MG)	80.000	90.000	100.000	75.000	70.000
CYS	(MG)	30.000	30.000	40.000	30.000	30.000
PHE	(MG)	170.000	170.000	200.000	160.000	150.000
TYR	(MG)	180.000	180.000	200.000	165.000	150.000
VAL	(MG)	240.000	250.000	290.000	225.000	210.000
HIS	(MG)	90.000	100.000	110.000	85.000	80.000
FAT-T	(GM)	3.500	0.100	2.000	12.100	20.600
SFA	(GM)	2.000	0.0	1.000	7.000	11.000
PUFA	(GM)	1.000	0.0	1.000	1.000	8.000
CHOLE	(GM)	0.014	0.002	0.002	0.008	0.070
CHO-T	(GM)	4.900	5.100	6.000	4.600	4.300
SUCR	(GM)	0.0	0.0	0.0	0.0	0.0
CHO-F	(GM)	0.0	0.0	0.0	0.0	0.0
THIA	(MG)	0.030	0.040	0.040	0.030	0.030
RIBO	(MG)	0.170	0.180	0.210	0.160	0.150
NIACIN	(MG)	0.100	0.100	0.100	0.100	0.100
VIT-B6	(MG)	40.000	40.000	40.000	35.000	30.000
FOLIC	(UG)	9.000	9.000	9.000	15.000	20.000
VIT-B12	(UG)	0.400	0.400	0.400	0.330	0.250
VIT-C	(MG)	1.000	1.000	1.000	1.000	1.000
PANTO	(UG)	300.000	400.000	400.000	300.000	300.000
BIOTIN	(MG)	4.000	2.000	3.000	4.000	4.000
VIT-A	(IU)	140.000	0.0	80.000	495.000	840.000
VIT-D	(IU)	41.000	41.000	41.000	28.000	15.000
VIT-E	(MG)	0.100	0.0	0.100	0.400	0.700
CA	(MG)	118.000	121.000	143.000	110.000	102.000
P	(MG)	93.000	95.000	112.000	87.000	80.000
MG	(MG)	13.000	15.000	17.000	12.000	10.000
FE	(MG)	0.0	0.0	0.100	0.0	0.0
I	(MG)	7.000	7.000	8.000	7.000	6.000
ZN	(MG)	0.400	0.400	0.400	0.400	0.300
NA	(MG)	50.000	52.000	61.000	47.000	43.000
K	(MG)	144.000	145.000	175.000	133.000	122.000
CU	(MG)	0.150	0.020	0.020	0.160	0.170

ITEM CLUSTER		141	142	143	144	145
ATTRIBUTE GROUP		31	31	32	32	32
NUTRIENTS:						
KCAL		352.000	137.000	47.000	41.000	23.000
PROT	(GM)	2.200	7.000	0.100	0.500	0.400
TRY	(MG)	30.000	100.000	0.0	1.000	2.000
THR	(MG)	100.000	320.000	3.000	1.000	1.000
ISO	(MG)	140.000	450.000	5.000	1.000	1.000
LEU	(MG)	220.000	690.000	5.000	1.000	1.000
LYS	(MG)	170.000	550.000	4.000	6.000	8.000
MET	(MG)	50.000	170.000	2.000	0.0	1.000
CYS	(MG)	20.000	60.000	1.000	1.000	1.000
PHE	(MG)	110.000	340.000	3.000	11.000	11.000
TYR	(MG)	110.000	360.000	2.000	6.000	6.000
VAL	(MG)	150.000	480.000	3.000	1.000	1.000
HIS	(MG)	60.000	190.000	2.000	1.000	1.000
FAT-T	(GM)	37.600	7.900	0.0	0.100	0.100
SFA	(GM)	21.000	7.000	0.0	0.0	0.0
PUFA	(GM)	13.000	3.000	0.0	0.0	0.0
CHOLE	(GM)	0.120	0.110	0.0	0.0	0.0
CHO-T	(GM)	3.100	9.700	11.900	9.800	7.600
SUCR	(GM)	2.000	0.0	5.500	2.700	0.100
CHO-F	(GM)	0.0	0.0	0.100	0.0	0.0
THIA	(MG)	0.020	0.040	0.010	0.030	0.030
RIBO	(MG)	0.110	0.340	0.020	0.020	0.010
NIACIN	(MG)	0.0	0.200	0.100	0.200	0.100
VIT-B6	(MG)	20.000	50.000	30.000	10.000	50.000
FOLIC	(UG)	15.000	1.000	0.0	1.000	2.000
VIT-B12	(UG)	0.100	0.160	0.0	0.0	0.0
VIT-C	(MG)	0.0	1.000	1.000	34.000	42.000
PANTO	(UG)	200.000	600.000	100.000	100.000	100.000
BIOTIN	(MG)	3.000	8.000	0.0	1.000	0.0
VIT-A	(IU)	1540.000	320.000	40.000	10.000	20.000
VIT-D	(IU)	11.000	79.000	0.0	0.0	0.0
VIT-E	(MG)	4.900	0.200	0.0	0.0	0.0
CA	(MG)	75.000	252.000	6.000	8.000	7.000
P	(MG)	59.000	205.000	9.000	14.000	10.000
MG	(MG)	7.000	33.000	4.000	7.000	9.000
FE	(MG)	0.0	0.100	0.600	0.400	0.200
I	(MG)	4.000	16.000	2.000	1.000	5.000
ZN	(MG)	0.200	0.700	0.100	0.0	0.200
NA	(MG)	32.000	118.000	1.000	1.000	1.000
K	(MG)	89.000	303.000	101.000	162.000	141.000
CU	(MG)	0.120	0.090	0.020	0.010	0.080

ITEM CLUSTER		146	147	148	149	150
ATTRIBUTE GROUP		32	32	32	32	33
NUTRIENTS:						
KCAL		44.000	48.000	45.000	49.000	21.000
PROT	(GM)	0.100	0.800	0.700	1.000	1.000
TRY	(MG)	0.0	3.000	3.000	3.000	10.000
THR	(MG)	0.0	1.000	1.000	1.000	30.000
ISO	(MG)	0.0	1.000	1.000	1.000	30.000
LEU	(MG)	0.0	1.000	1.000	1.000	40.000
LYS	(MG)	0.0	21.000	21.000	24.000	40.000
MET	(MG)	0.0	2.000	2.000	3.000	10.000
CYS	(MG)	0.0	1.000	1.000	1.000	10.000
PHE	(MG)	0.0	9.000	9.000	12.000	20.000
TYR	(MG)	0.0	15.000	15.000	21.000	10.000
VAL	(MG)	0.0	1.000	1.000	1.000	30.000
HIS	(MG)	0.0	1.000	1.000	1.000	20.000
FAT-T	(GM)	0.0	0.200	0.100	0.200	0.200
SFA	(GM)	0.0	0.0	0.0	0.0	0.0
PUFA	(GM)	0.0	0.0	0.0	0.0	0.0
CHOLE	(GM)	0.0	0.0	0.0	0.0	0.0
CHO-T	(GM)	11.400	11.200	10.700	12.200	4.300
SUCR	(GM)	4.900	3.200	3.200	4.200	0.300
CHO-F	(GM)	0.0	0.100	0.0	0.500	0.400
THIA	(MG)	0.0	0.070	0.090	0.100	0.050
RIBO	(MG)	0.010	0.020	0.010	0.040	0.030
NIACIN	(MG)	0.100	0.300	0.300	0.400	0.700
VIT-B6	(MG)	10.000	40.000	30.000	60.000	90.000
FOLIC	(UG)	2.000	4.000	4.000	45.000	26.000
VIT-B12	(UG)	0.0	0.0	0.0	0.0	0.0
VIT-C	(MG)	7.000	40.000	45.000	50.000	17.000
PANTO	(UG)	0.0	200.000	200.000	300.000	200.000
BIOTIN	(MG)	0.0	1.000	0.0	2.000	2.000
VIT-A	(IU)	0.0	200.000	200.000	200.000	900.000
VIT-D	(IU)	0.0	0.0	0.0	0.0	0.0
VIT-E	(MG)	0.0	0.0	0.0	0.200	0.0
CA	(MG)	1.000	10.000	9.000	41.000	6.000
P	(MG)	1.000	18.000	16.000	20.000	19.000
MG	(MG)	1.000	11.000	12.000	11.000	11.000
FE	(MG)	0.0	0.400	0.100	0.400	0.500
I	(MG)	7.000	1.000	1.000	0.0	0.0
ZN	(MG)	0.100	0.200	0.100	0.100	0.100
NA	(MG)	0.0	1.000	1.000	1.000	130.000
K	(MG)	16.000	199.000	186.000	200.000	217.000
CU	(MG)	0.010	0.050	0.050	0.090	0.130

ITEM CLUSTER		151	152	153	154	155
ATTRIBUTE GROUP		34	34	35	35	36
NUTRIENTS:						
KCAL		39.000	31.000	1.000	2.000	42.000
PROT	(GM)	0.0	0.0	0.0	0.0	0.300
TRY	(MG)	0.0	0.0	0.0	0.0	0.0
THR	(MG)	0.0	0.0	0.0	0.0	0.0
ISO	(MG)	0.0	0.0	0.0	0.0	0.0
LEU	(MG)	0.0	0.0	0.0	0.0	0.0
LYS	(MG)	0.0	0.0	0.0	0.0	0.0
MET	(MG)	0.0	0.0	0.0	0.0	0.0
CYS	(MG)	0.0	0.0	0.0	0.0	0.0
PHE	(MG)	0.0	0.0	0.0	0.0	0.0
TYR	(MG)	0.0	0.0	0.0	0.0	0.0
VAL	(MG)	0.0	0.0	0.0	0.0	0.0
HIS	(MG)	0.0	0.0	0.0	0.0	0.0
FAT-T	(GM)	0.0	0.0	0.0	0.0	0.0
SFA	(GM)	0.0	0.0	0.0	0.0	0.0
PUFA	(GM)	0.0	0.0	0.0	0.0	0.0
CHOLE	(GM)	0.0	0.0	0.0	0.0	0.0
CHO-T	(GM)	10.000	8.000	0.0	0.400	3.800
SUCR	(GM)	10.000	8.000	0.0	0.0	0.0
CHO-F	(GM)	0.0	0.0	0.0	0.0	0.0
THIA	(MG)	0.0	0.0	0.0	0.0	0.0
RIBO	(MG)	0.0	0.0	0.0	0.010	0.030
NIACIN	(MG)	0.0	0.0	0.300	0.0	0.600
VIT-B6	(MG)	0.0	0.0	10.000	0.0	60.000
FOLIC	(UG)	0.0	0.0	0.0	0.0	0.0
VIT-B12	(UG)	0.0	0.0	0.0	0.0	0.0
VIT-C	(MG)	0.0	0.0	0.0	0.0	0.0
PANTO	(UG)	0.0	0.0	0.0	0.0	100.000
BIOTIN	(MG)	0.0	0.0	0.0	0.0	0.0
VIT-A	(IU)	0.0	0.0	0.0	0.0	0.0
VIT-D	(IU)	0.0	0.0	0.0	0.0	0.0
VIT-E	(MG)	0.0	0.0	0.0	0.0	0.0
CA	(MG)	8.000	8.000	2.000	0.0	5.000
P	(MG)	15.000	15.000	4.000	0.0	30.000
MG	(MG)	1.000	1.000	5.000	2.000	10.000
FE	(MG)	0.400	0.400	0.100	0.0	0.0
I	(MG)	1.000	1.000	4.000	16.000	1.000
ZN	(MG)	0.100	0.100	0.0	0.0	0.100
NA	(MG)	6.000	6.000	1.000	0.0	7.000
K	(MG)	0.0	0.0	36.000	25.000	25.000
CU	(MG)	0.040	0.030	0.020	0.010	0.070

ITEM CLUSTER		156	157	158	159	160
ATTRIBUTE GROUP		36	36	36	37	37
NUTRIENTS:						
KCAL		249.000	137.000	85.000	26.000	73.000
PROT	(GM)	0.0	0.100	0.100	1.400	3.000
TRY	(MG)	0.0	0.0	0.0	10.000	40.000
THR	(MG)	0.0	0.0	0.0	70.000	130.000
ISO	(MG)	0.0	0.0	0.0	80.000	290.000
LEU	(MG)	0.0	0.0	0.0	80.000	230.000
LYS	(MG)	0.0	0.0	0.0	180.000	260.000
MET	(MG)	0.0	0.0	0.0	40.000	90.000
CYS	(MG)	0.0	0.0	0.0	60.000	120.000
PHE	(MG)	0.0	0.0	0.0	60.000	120.000
TYR	(MG)	0.0	0.0	0.0	30.000	50.000
VAL	(MG)	0.0	0.0	0.0	60.000	170.000
HIS	(MG)	0.0	0.0	0.0	20.000	40.000
FAT-T	(GM)	0.0	0.0	0.0	0.800	4.200
SFA	(GM)	0.0	0.0	0.0	0.0	1.000
PUFA	(GM)	0.0	0.0	0.0	0.0	2.000
CHOLE	(GM)	0.0	0.0	0.0	0.003	0.009
CHO-T	(GM)	0.0	7.700	4.200	3.300	5.900
SUCR	(GM)	0.0	7.700	4.200	0.0	0.0
CHO-F	(GM)	0.0	0.0	0.0	0.100	0.100
THIA	(MG)	0.0	0.010	0.0	0.010	0.200
RIBO	(MG)	0.0	0.020	0.010	0.010	0.110
NIACIN	(MG)	0.0	0.200	0.100	0.300	0.300
VIT-B6	(MG)	0.0	40.000	40.000	30.000	30.000
FOLIC	(UG)	0.0	0.0	0.0	0.0	4.000
VIT-B12	(UG)	0.0	0.0	0.0	0.0	0.200
VIT-C	(MG)	0.0	0.0	0.0	0.0	1.000
PANTO	(UG)	0.0	0.0	0.0	100.000	200.000
BIOTIN	(MG)	0.0	0.0	0.0	1.000	1.000
VIT-A	(IU)	0.0	0.0	0.0	20.000	250.000
VIT-D	(IU)	0.0	0.0	0.0	0.0	1.000
VIT-E	(MG)	0.0	0.0	0.0	0.0	0.0
CA	(MG)	8.000	8.000	9.000	4.000	70.000
P	(MG)	10.000	10.000	10.000	15.000	62.000
MG	(MG)	0.0	5.000	8.000	4.000	9.000
FE	(MG)	0.400	0.400	0.400	0.200	0.200
I	(MG)	1.000	1.000	1.000	1.000	4.000
ZN	(MG)	0.100	0.100	0.100	0.300	0.400
NA	(MG)	1.000	4.000	5.000	408.000	430.000
K	(MG)	2.000	75.000	92.000	23.000	106.000
CU	(MG)	0.080	0.080	0.110	0.130	0.050

ITEM CLUSTER		161	162	163	164	165
ATTRIBUTE GROUP		37	37	37	37	38
NUTRIENTS:						
KCAL		59.000	36.000	32.000	3.000	259.000
PROT	(GM)	3.500	0.800	2.100	0.400	5.700
TRY	(MG)	30.000	10.000	20.000	5.000	90.000
THR	(MG)	130.000	30.000	90.000	18.000	210.000
ISO	(MG)	190.000	30.000	70.000	21.000	330.000
LEU	(MG)	250.000	30.000	170.000	33.000	550.000
LYS	(MG)	210.000	80.000	230.000	35.000	170.000
MET	(MG)	30.000	30.000	40.000	10.000	90.000
CYS	(MG)	30.000	10.000	30.000	5.000	100.000
PHE	(MG)	800.000	20.000	90.000	7.000	310.000
TYR	(MG)	80.000	10.000	30.000	14.000	220.000
VAL	(MG)	190.000	30.000	120.000	22.000	310.000
HIS	(MG)	80.000	20.000	30.000	14.000	200.000
FAT-T	(GM)	1.300	1.000	0.900	0.100	0.200
SFA	(GM)	0.0	0.0	0.0	0.0	0.0
PUFA	(GM)	0.0	0.0	0.0	0.0	0.0
CHOLE	(GM)	0.002	0.002	0.003	0.0	0.0
CHO-T	(GM)	8.400	6.400	3.900	0.100	59.400
SUCR	(GM)	2.600	0.400	0.100	0.0	35.000
CHO-F	(GM)	0.200	0.200	0.200	0.0	0.0
THIA	(MG)	0.100	0.020	0.020	0.0	0.0
RIBO	(MG)	0.060	0.020	0.020	0.010	0.110
NIACIN	(MG)	0.600	0.500	0.400	0.500	0.100
VIT-B6	(MG)	50.000	20.000	30.000	0.0	10.000
FOLIC	(UG)	1.000	4.000	4.000	0.0	2.000
VIT-B12	(UG)	0.160	0.0	0.0	0.0	0.040
VIT-C	(MG)	0.0	5.000	2.000	0.0	0.0
PANTO	(UG)	100.000	100.000	100.000	0.0	200.000
BIOTIN	(MG)	1.000	3.000	1.000	0.0	4.000
VIT-A	(IU)	180.000	410.000	100.000	0.0	0.0
VIT-D	(IU)	1.000	1.000	0.0	0.0	0.0
VIT-E	(MG)	0.0	0.0	0.100	0.0	0.0
CA	(MG)	12.000	6.000	5.000	0.0	95.000
P	(MG)	61.000	14.000	20.000	6.000	119.000
MG	(MG)	6.000	7.000	11.000	1.000	15.000
FE	(MG)	0.600	0.300	0.300	0.100	0.300
I	(MG)	1.000	3.000	2.000	1.000	3.000
ZN	(MG)	0.400	0.300	0.300	0.0	0.200
NA	(MG)	384.000	396.000	427.000	48.000	146.000
K	(MG)	110.000	94.000	66.000	2.000	60.000
CU	(MG)	0.090	0.160	0.090	0.0	0.040

ITEM CLUSTER		166	167	168	169	170
ATTRIBUTE GROUP		38	38	38	38	38
NUTRIENTS:						
KCAL		322.000	380.000	379.000	411.000	337.000
PROT	(GM)	6.300	4.300	4.800	6.400	4.100
TRY	(MG)	130.000	80.000	90.000	130.000	80.000
THR	(MG)	360.000	210.000	230.000	360.000	210.000
ISO	(MG)	510.000	340.000	340.000	520.000	300.000
LEU	(MG)	760.000	530.000	530.000	770.000	470.000
LYS	(MG)	1150.000	270.000	270.000	1160.000	240.000
MET	(MG)	200.000	120.000	120.000	210.000	110.000
CYS	(MG)	180.000	120.000	120.000	180.000	100.000
PHE	(MG)	340.000	240.000	260.000	350.000	230.000
TYR	(MG)	350.000	250.000	250.000	350.000	220.000
VAL	(MG)	540.000	350.000	350.000	550.000	310.000
HIS	(MG)	200.000	330.000	330.000	200.000	290.000
FAT-T	(GM)	9.600	17.600	15.300	18.700	11.300
SFA	(GM)	3.000	9.000	6.000	5.000	5.000
PUFA	(GM)	6.000	8.000	9.000	12.000	6.000
CHOLE	(GM)	0.080	0.070	0.100	0.160	0.090
CHO-T	(GM)	52.400	55.600	59.700	54.700	57.600
SUCR	(GM)	19.100	43.000	26.700	28.100	36.200
CHO-F	(GM)	0.100	0.300	0.600	0.100	0.200
THIA	(MG)	0.180	0.020	0.130	0.040	0.020
RIBO	(MG)	0.160	0.080	0.140	0.110	0.080
NIACIN	(MG)	1.400	0.200	0.800	0.200	0.200
VIT-B6	(MG)	40.000	50.000	80.000	40.000	40.000
FOLIC	(UG)	8.000	32.000	3.000	8.000	8.000
VIT-B12	(UG)	0.0	0.0	0.130	0.0	0.0
VIT-C	(MG)	0.0	0.0	0.0	0.0	0.0
PANTO	(UG)	200.000	200.000	400.000	300.000	300.000
BIOTIN	(MG)	5.000	6.000	8.000	3.000	5.000
VIT-A	(IU)	160.000	430.000	120.000	290.000	140.000
VIT-D	(IU)	6.000	9.000	13.000	20.000	2.000
VIT-E	(MG)	0.200	0.100	0.700	1.100	0.500
CA	(MG)	61.000	54.000	72.000	40.000	91.000
P	(MG)	174.000	92.000	113.000	104.000	182.000
MG	(MG)	15.000	24.000	16.000	13.000	20.000
FE	(MG)	1.600	0.800	2.600	0.800	0.600
I	(MG)	7.000	7.000	7.000	7.000	7.000
ZN	(MG)	0.600	0.500	0.600	0.600	0.500
NA	(MG)	431.000	420.000	158.000	178.000	227.000
K	(MG)	109.000	119.000	496.000	78.000	109.000
CU	(MG)	0.080	0.310	0.100	0.060	0.100

ITEM CLUSTER		171	172	173	174	175
ATTRIBUTE GROUP		39	39	40	40	41
NUTRIENTS:						
KCAL		256.000	211.000	480.000	358.000	391.000
PROT	(GM)	2.200	4.000	5.100	3.900	4.600
TRY	(MG)	30.000	60.000	60.000	50.000	60.000
THR	(MG)	60.000	170.000	150.000	110.000	160.000
ISO	(MG)	100.000	250.000	230.000	190.000	240.000
LEU	(MG)	170.000	340.000	390.000	300.000	380.000
LYS	(MG)	50.000	260.000	120.000	90.000	170.000
MET	(MG)	30.000	110.000	70.000	50.000	80.000
CYS	(MG)	40.000	70.000	100.000	80.000	140.000
PHE	(MG)	120.000	220.000	280.000	210.000	250.000
TYR	(MG)	80.000	160.000	170.000	130.000	200.000
VAL	(MG)	100.000	260.000	220.000	170.000	240.000
HIS	(MG)	40.000	90.000	100.000	80.000	90.000
FAT-T	(GM)	11.100	11.200	20.200	5.600	18.600
SFA	(GM)	3.000	3.000	4.000	1.000	4.000
PUFA	(GM)	8.000	8.000	15.000	3.000	13.000
CHOLE	(GM)	0.030	0.100	0.100	0.060	0.045
CHO-T	(GM)	38.100	24.500	71.000	75.400	51.400
SUCR	(GM)	10.900	15.100	37.100	25.700	16.100
CHO-F	(GM)	0.400	0.500	0.100	1.700	0.100
THIA	(MG)	0.020	0.030	0.030	0.040	0.160
RIBO	(MG)	0.020	0.100	0.050	0.070	0.160
NIACIN	(MG)	0.400	0.500	0.400	0.300	1.200
VIT-B6	(MG)	40.000	40.000	50.000	90.000	40.000
FOLIC	(UG)	4.000	4.000	11.000	10.000	9.000
VIT-B12	(UG)	0.0	0.0	0.0	0.0	0.0
VIT-C	(MG)	1.000	0.0	0.0	0.0	0.0
PANTO	(UG)	100.000	500.000	400.000	300.000	400.000
BIOTIN	(MG)	1.000	5.000	5.000	5.000	3.000
VIT-A	(IU)	30.000	2470.000	80.000	110.000	80.000
VIT-D	(IU)	0.0	10.000	1.000	1.000	3.000
VIT-E	(MG)	0.900	0.900	0.500	0.400	0.400
CA	(MG)	8.000	51.000	37.000	78.000	40.000
P	(MG)	22.000	69.000	163.000	60.000	190.000
MG	(MG)	4.000	6.000	15.000	23.000	16.000
FE	(MG)	0.300	0.500	0.700	1.000	1.400
I	(MG)	4.000	3.000	10.000	10.000	7.000
ZN	(MG)	0.400	0.400	1.700	0.900	0.700
NA	(MG)	301.000	214.000	365.000	252.000	501.000
K	(MG)	80.000	160.000	67.000	198.000	90.000
CU	(MG)	0.080	0.050	0.150	0.190	0.110

ITEM CLUSTER		176	177	178	179	180
ATTRIBUTE GROUP		41	41	42	42	42
NUTRIENTS:						
KCAL		414.000	322.000	207.000	134.000	31.000
PROT	(GM)	6.300	6.300	4.000	0.900	0.0
TRY	(MG)	80.000	130.000	60.000	10.000	0.0
THR	(MG)	220.000	360.000	180.000	40.000	0.0
ISO	(MG)	320.000	510.000	260.000	60.000	0.0
LEU	(MG)	510.000	760.000	400.000	90.000	0.0
LYS	(MG)	220.000	1150.000	310.000	70.000	0.0
MET	(MG)	110.000	200.000	100.000	20.000	0.0
CYS	(MG)	70.000	180.000	40.000	10.000	0.0
PHE	(MG)	340.000	340.000	190.000	40.000	0.0
TYR	(MG)	160.000	350.000	200.000	50.000	0.0
VAL	(MG)	260.000	540.000	280.000	60.000	0.0
HIS	(MG)	90.000	200.000	110.000	20.000	0.0
FAT-T	(GM)	26.700	9.600	12.500	1.200	0.0
SFA	(GM)	6.000	3.000	7.000	0.0	0.0
PUFA	(GM)	19.000	6.000	4.000	0.0	0.0
CHOLE	(GM)	0.040	0.080	0.040	0.0	0.0
CHO-T	(GM)	37.700	52.400	20.600	30.800	8.000
SUCR	(GM)	15.100	19.100	15.600	29.300	8.000
CHO-F	(GM)	0.200	0.100	0.0	0.0	0.0
THIA	(MG)	0.160	0.180	0.040	0.010	0.0
RIBO	(MG)	0.170	0.160	0.190	0.030	0.0
NIACIN	(MG)	1.300	1.400	0.100	0.0	0.0
VIT-B6	(MG)	40.000	40.000	30.000	30.000	0.0
FOLIC	(UG)	8.000	8.000	1.000	3.000	0.0
VIT-B12	(UG)	0.0	0.0	0.250	0.0	0.0
VIT-C	(MG)	0.0	0.0	1.000	2.000	0.0
PANTO	(UG)	500.000	200.000	500.000	300.000	0.0
BIOTIN	(MG)	3.000	5.000	4.000	1.000	0.0
VIT-A	(IU)	60.000	160.000	520.000	60.000	0.0
VIT-D	(IU)	1.000	6.000	5.000	0.0	0.0
VIT-E	(MG)	0.700	0.200	0.100	0.100	0.0
CA	(MG)	38.000	61.000	123.000	16.000	8.000
P	(MG)	76.000	174.000	99.000	13.000	15.000
MG	(MG)	16.000	15.000	18.000	9.000	1.000
FE	(MG)	1.500	1.600	0.100	0.0	0.400
I	(MG)	7.000	7.000	12.000	2.000	1.000
ZN	(MG)	0.700	0.600	0.500	0.200	0.100
NA	(MG)	234.000	431.000	40.000	10.000	6.000
K	(MG)	80.000	109.000	112.000	22.000	0.0
CU	(MG)	0.110	0.080	0.020	0.020	0.030

ITEM CLUSTER		181	182	183	184	185
ATTRIBUTE GROUP		43	43	44	44	44
NUTRIENTS:						
KCAL		124.000	59.000	58.000	91.000	85.000
PROT	(GM)	3.400	4.200	0.200	0.200	1.100
TRY	(MG)	60.000	60.000	0.0	0.0	18.000
THR	(MG)	190.000	190.000	6.000	6.000	27.000
ISO	(MG)	270.000	270.000	11.000	11.000	56.000
LEU	(MG)	400.000	420.000	10.000	10.000	59.000
LYS	(MG)	270.000	330.000	8.000	8.000	55.000
MET	(MG)	110.000	100.000	3.000	3.000	11.000
CYS	(MG)	240.000	40.000	1.000	1.000	16.000
PHE	(MG)	220.000	200.000	6.000	6.000	34.000
TYR	(MG)	200.000	200.000	3.000	3.000	33.000
VAL	(MG)	280.000	290.000	7.000	7.000	65.000
HIS	(MG)	110.000	110.000	3.000	3.000	1.000
FAT-T	(GM)	3.000	2.000	0.600	0.100	0.200
SFA	(GM)	2.000	1.000	0.0	0.0	0.0
PUFA	(GM)	1.000	1.000	0.0	0.0	0.0
CHOLE	(GM)	0.050	0.002	0.0	0.0	0.0
CHO-T	(GM)	22.800	6.000	14.500	23.800	22.200
SUCR	(GM)	15.000	0.0	3.300	12.600	8.700
CHO-F	(GM)	0.100	0.0	1.000	0.500	0.500
THIA	(MG)	0.020	0.040	0.030	0.020	0.050
RIBO	(MG)	0.150	0.210	0.020	0.010	0.060
NIACIN	(MG)	0.100	0.100	0.100	0.0	0.700
VIT-B6	(MG)	50.000	40.000	30.000	30.000	320.000
FOLIC	(UG)	7.000	9.000	2.000	2.000	27.000
VIT-B12	(UG)	0.250	0.400	0.0	0.0	0.0
VIT-C	(MG)	0.0	1.000	4.000	1.000	10.000
PANTO	(UG)	500.000	400.000	100.000	100.000	300.000
BIOTIN	(MG)	5.000	3.000	1.000	1.000	4.000
VIT-A	(IU)	130.000	80.000	90.000	40.000	190.000
VIT-D	(IU)	2.000	41.000	0.0	0.0	0.0
VIT-E	(MG)	0.700	0.100	0.600	0.100	0.400
CA	(MG)	102.000	143.000	7.000	4.000	8.000
P	(MG)	95.000	112.000	10.000	5.000	26.000
MG	(MG)	23.000	17.000	5.000	4.000	31.000
FE	(MG)	0.300	0.100	0.300	0.500	0.700
I	(MG)	7.000	8.000	3.000	13.000	8.000
ZN	(MG)	2.600	0.400	0.0	0.900	0.200
NA	(MG)	129.000	61.000	1.000	2.000	1.000
K	(MG)	136.000	175.000	110.000	65.000	370.000
CU	(MG)	0.120	0.020	0.080	0.010	0.130

		186	187	188	189	190
ITEM CLUSTER		186	187	188	189	190
ATTRIBUTE GROUP		44	44	44	44	44
NUTRIENTS:						
KCAL		30.000	41.000	49.000	78.000	38.000
PROT	(GM)	0.700	0.500	1.000	0.400	0.600
TRY	(MG)	1.000	1.000	3.000	1.000	1.000
THR	(MG)	1.000	1.000	1.000	1.000	1.000
ISO	(MG)	1.000	1.000	1.000	1.000	1.000
LEU	(MG)	1.000	1.000	1.000	1.000	1.000
LYS	(MG)	15.000	6.000	24.000	1.000	1.000
MET	(MG)	2.000	0.0	3.000	1.000	1.000
CYS	(MG)	1.000	1.000	1.000	1.000	1.000
PHE	(MG)	21.000	11.000	12.000	8.000	12.000
TYR	(MG)	12.000	6.000	21.000	10.000	15.000
VAL	(MG)	1.000	1.000	1.000	1.000	1.000
HIS	(MG)	1.000	1.000	1.000	1.000	1.000
FAT-T	(GM)	0.100	0.100	0.200	0.100	0.100
SFA	(GM)	0.0	0.0	0.0	0.0	0.0
PUFA	(GM)	0.0	0.0	0.0	0.0	0.0
CHOLE	(GM)	0.0	0.0	0.0	0.0	0.0
CHO-T	(GM)	7.500	10.600	12.200	20.100	9.700
SUCR	(GM)	4.400	2.900	4.200	16.300	5.900
CHO-F	(GM)	0.300	0.200	0.500	0.400	0.600
THIA	(MG)	0.040	0.040	0.100	0.010	0.020
RIBO	(MG)	0.030	0.020	0.040	0.020	0.050
NIACIN	(MG)	0.600	0.200	0.400	0.600	1.000
VIT-B6	(MG)	90.000	30.000	60.000	20.000	20.000
FOLIC	(UG)	8.000	2.000	45.000	11.000	11.000
VIT-B12	(UG)	0.0	0.0	0.0	0.0	0.0
VIT-C	(MG)	33.000	38.000	50.000	3.000	7.000
PANTO	(UG)	300.000	300.000	300.000	100.000	200.000
BIOTIN	(MG)	3.000	3.000	2.000	0.0	2.000
VIT-A	(IU)	3400.000	80.000	200.000	430.000	1330.000
VIT-D	(IU)	0.0	0.0	0.0	0.0	0.0
VIT-E	(MG)	0.100	0.300	0.200	0.0	0.500
CA	(MG)	14.000	16.000	41.000	4.000	9.000
P	(MG)	16.000	16.000	20.000	12.000	19.000
MG	(MG)	14.000	9.000	11.000	6.000	11.000
FE	(MG)	0.400	0.400	0.400	0.300	0.500
I	(MG)	2.000	1.000	0.0	16.000	6.000
ZN	(MG)	0.100	0.100	0.100	0.0	0.0
NA	(MG)	12.000	1.000	1.000	2.000	1.000
K	(MG)	251.000	135.000	200.000	130.000	202.000
CU	(MG)	0.040	0.040	0.090	0.070	0.050

ITEM CLUSTER		191	192	193	194	195
ATTRIBUTE GROUP		44	44	45	46	47
NUTRIENTS:						
KCAL		74.0CC	52.000	289.000	59.000	304.000
PROT	(GM)	0.30C	0.400	2.500	1.500	0.300
TRY	(MG)	5.00C	5.000	61.000	0.0	0.0
THR	(MG)	1.000	1.000	61.000	30.000	0.0
ISO	(MG)	1.000	1.000	74.000	20.000	0.0
LEU	(MG)	1.000	1.000	77.000	50.000	0.0
LYS	(MG)	9.000	9.000	65.000	80.000	0.0
MET	(MG)	1.000	1.000	27.000	10.000	0.0
CYS	(MG)	1.00C	1.000	1.000	0.0	0.0
PHE	(MG)	8.000	8.000	75.000	40.000	0.0
TYR	(MG)	8.000	8.000	19.000	10.000	0.0
VAL	(MG)	1.000	1.000	94.000	40.000	0.0
HIS	(MG)	1.000	1.000	49.000	10.000	0.0
FAT-T	(GM)	0.100	0.200	0.200	0.0	0.0
SFA	(GM)	0.0	0.0	0.0	0.0	0.0
PUFA	(GM)	0.0	0.0	0.0	0.0	0.0
CHOLE	(GM)	0.0	0.0	0.0	0.0	0.0
CHO-T	(GM)	19.400	13.700	77.400	14.100	82.300
SUCR	(GM)	13.100	7.400	14.200	14.100	1.900
CHO-F	(GM)	0.300	0.400	0.900	0.0	0.0
THIA	(MG)	0.080	0.090	0.110	0.0	0.0
RIBO	(MG)	0.020	0.030	0.080	0.0	0.040
NIACIN	(MG)	0.200	0.200	0.500	0.0	0.300
VIT-B6	(MG)	70.00C	90.000	240.000	0.0	20.000
FOLIC	(UG)	2.000	1.000	9.000	0.0	3.000
VIT-B12	(UG)	0.0	0.0	0.0	0.0	0.0
VIT-C	(MG)	7.000	17.000	1.000	0.0	1.000
PANTO	(UG)	200.000	200.000	100.000	0.0	200.000
BIOTIN	(MG)	1.000	2.000	5.000	0.0	0.0
VIT-A	(IU)	50.000	70.000	20.000	0.0	0.0
VIT-D	(IU)	0.0	C.0	0.0	0.0	0.0
VIT-E	(MG)	0.0	0.600	0.300	0.0	0.0
CA	(MG)	11.00C	17.000	62.000	0.0	5.000
P	(MG)	5.000	8.000	101.000	0.0	6.000
MG	(MG)	8.000	12.000	31.000	1.000	4.000
FE	(MG)	0.300	0.500	3.500	0.0	0.500
I	(MG)	2.000	16.000	3.000	1.000	2.000
ZN	(MG)	0.200	0.200	0.200	0.500	0.900
NA	(MG)	1.000	1.000	27.000	51.000	5.000
K	(MG)	96.00C	146.000	763.000	0.0	51.000
CU	(MG)	0.150	0.070	0.230	0.0	1.670

ITEM CLUSTER		196	197	198	199	200
ATTRIBUTE GROUP		47	47	48	48	49
NUTRIENTS:						
KCAL		232.000	385.000	273.000	290.000	399.000
PROT	(GM)	0.0	0.0	0.100	0.0	4.000
TRY	(MG)	0.0	0.0	0.0	0.0	60.000
THR	(MG)	0.0	0.0	0.0	0.0	180.000
ISO	(MG)	0.0	0.0	0.0	0.0	260.000
LEU	(MG)	0.0	0.0	0.0	0.0	400.000
LYS	(MG)	0.0	0.0	0.0	0.0	310.000
MET	(MG)	0.0	0.0	0.0	0.0	100.000
CYS	(MG)	0.0	0.0	0.0	0.0	40.000
PHE	(MG)	0.0	0.0	0.0	0.0	140.000
TYR	(MG)	0.0	0.0	0.0	0.0	200.000
VAL	(MG)	0.0	0.0	0.0	0.0	280.000
HIS	(MG)	0.0	0.0	0.0	0.0	110.000
FAT-T	(GM)	0.0	0.0	0.100	0.0	10.200
SFA	(GM)	0.0	0.0	0.0	0.0	5.000
PUFA	(GM)	0.0	0.0	0.0	0.0	5.000
CHOLE	(GM)	0.0	0.0	0.0	0.0	0.0
CHO-T	(GM)	60.000	99.500	70.600	75.000	76.600
SUCR	(GM)	53.600	99.500	53.000	4.500	64.400
CHO-F	(GM)	2.000	0.0	0.0	0.0	0.200
THIA	(MG)	0.090	0.0	0.010	0.0	0.030
RIBO	(MG)	0.120	0.0	0.030	0.0	0.170
NIACIN	(MG)	1.200	0.0	0.200	0.0	0.200
VIT-B6	(MG)	200.000	0.0	30.000	0.0	20.000
FOLIC	(UG)	10.000	0.0	1.000	0.0	4.000
VIT-B12	(UG)	0.0	0.0	0.0	0.0	0.0
VIT-C	(MG)	0.0	0.0	4.000	0.0	0.0
PANTO	(UG)	400.000	0.0	100.000	0.0	0.0
BIOTIN	(MG)	9.000	0.0	1.000	0.0	5.000
VIT-A	(IU)	0.0	0.0	10.000	0.0	10.000
VIT-D	(IU)	0.0	0.0	0.0	0.0	40.000
VIT-E	(MG)	0.200	0.0	0.0	0.0	0.300
CA	(MG)	290.000	0.0	21.000	46.000	148.000
P	(MG)	69.000	0.0	7.000	16.000	122.000
MG	(MG)	81.000	0.0	4.000	2.000	0.0
FE	(MG)	6.000	8.000	1.500	4.100	1.400
I	(MG)	4.000	0.0	1.000	4.000	7.000
ZN	(MG)	4.600	0.0	0.500	1.300	1.100
NA	(MG)	37.000	1.000	17.000	68.000	226.000
K	(MG)	1063.000	3.000	75.000	4.000	192.000
CU	(MG)	1.170	0.030	0.110	0.090	0.040

ITEM CLUSTER		201	202	203	204	205
ATTRIBUTE GROUP		49	49	49	50	51
NUTRIENTS:						
KCAL		520.000	385.000	273.000	122.000	192.000
PROT	(GM)	7.700	0.0	0.100	6.100	7.300
TRY	(MG)	40.000	0.0	0.0	50.000	110.000
THR	(MG)	90.000	0.0	0.0	260.000	330.000
ISO	(MG)	120.000	0.0	0.0	350.000	480.000
LEU	(MG)	240.000	0.0	0.0	520.000	790.000
LYS	(MG)	130.000	0.0	0.0	450.000	530.000
MET	(MG)	20.000	0.0	0.0	60.000	190.000
CYS	(MG)	80.000	0.0	0.0	20.000	160.000
PHE	(MG)	160.000	0.0	0.0	310.000	300.000
TYR	(MG)	90.000	0.0	0.0	180.000	330.000
VAL	(MG)	140.000	0.0	0.0	370.000	480.000
HIS	(MG)	40.000	0.0	0.0	200.000	270.000
FAT-T	(GM)	32.300	0.0	0.100	2.600	9.900
SFA	(GM)	19.000	0.0	0.0	1.000	3.000
PUFA	(GM)	12.000	0.0	0.0	1.000	7.000
CHOLE	(GM)	0.015	0.0	0.0	0.001	0.020
CHO-T	(GM)	56.900	99.500	70.600	19.000	18.000
SUCR	(GM)	43.000	99.500	53.000	3.600	0.300
CHO-F	(GM)	0.400	0.0	0.0	1.400	0.100
THIA	(MG)	0.060	0.0	0.010	0.080	0.030
RIBO	(MG)	0.340	0.0	0.030	0.030	0.060
NIACIN	(MG)	0.300	0.0	0.200	0.600	1.200
VIT-B6	(MG)	20.000	0.0	30.000	380.000	110.000
FOLIC	(UG)	8.000	0.0	1.000	10.000	5.000
VIT-B12	(UG)	0.0	0.0	0.0	0.0	0.490
VIT-C	(MG)	0.0	0.0	4.000	2.000	0.0
PANTO	(UG)	100.000	0.0	100.000	100.000	400.000
BIOTIN	(MG)	32.000	0.0	1.000	6.000	2.000
VIT-A	(IU)	270.000	0.0	10.000	130.000	410.000
VIT-D	(IU)	88.000	0.0	0.0	0.0	0.0
VIT-E	(MG)	1.100	0.0	0.0	0.100	0.400
CA	(MG)	228.000	0.0	21.000	54.000	10.000
P	(MG)	231.000	0.0	7.000	92.000	48.000
MG	(MG)	82.000	0.0	4.000	28.000	11.000
FE	(MG)	1.100	0.100	1.500	1.800	1.000
I	(MG)	14.000	8.000	1.000	4.000	3.000
ZN	(MG)	2.600	0.0	0.500	1.400	1.000
NA	(MG)	94.000	1.000	17.000	463.000	366.000
K	(MG)	384.000	3.000	75.000	210.000	93.000
CU	(MG)	1.000	0.030	0.110	0.210	0.060

ITEM CLUSTER		206	207	208	209	210
ATTRIBUTE GROUP		52	53	54	55	56
NUTRIENTS:						
KCAL		89.000	38.000	102.000	133.000	173.000
PROT	(GM)	6.400	2.600	12.400	7.500	12.800
TRY	(MG)	80.000	30.000	120.000	70.000	160.000
THR	(MG)	260.000	90.000	440.000	300.000	520.000
ISO	(MG)	470.000	110.000	540.000	410.000	660.000
LEU	(MG)	590.000	170.000	800.000	630.000	940.000
LYS	(MG)	470.000	190.000	900.000	620.000	960.000
MET	(MG)	150.000	60.000	270.000	140.000	300.000
CYS	(MG)	110.000	30.000	130.000	90.000	180.000
PHE	(MG)	350.000	490.000	260.000	360.000	100.000
TYR	(MG)	250.000	70.000	360.000	270.000	400.000
VAL	(MG)	380.000	100.000	500.000	430.000	500.000
HIS	(MG)	690.000	60.000	300.000	240.000	300.000
FAT-T	(GM)	4.300	0.100	4.000	6.100	8.500
SFA	(GM)	2.000	0.0	1.000	3.000	3.000
PUFA	(GM)	2.000	0.0	2.000	3.000	4.000
CHOLE	(GM)	0.020	0.006	0.020	0.015	0.050
CHO-T	(GM)	6.200	7.100	4.000	12.200	11.300
SUCR	(GM)	0.300	1.000	0.500	8.900	1.200
CHO-F	(GM)	0.400	0.300	0.300	0.600	0.400
THIA	(MG)	0.060	0.020	0.030	0.030	0.070
RIBO	(MG)	0.070	0.040	0.090	0.070	0.180
NIACIN	(MG)	1.900	0.400	1.700	1.300	5.200
VIT-B6	(MG)	110.000	180.000	180.000	100.000	300.000
FOLIC	(UG)	3.000	5.000	5.000	9.000	6.000
VIT-B12	(UG)	0.650	0.660	0.660	0.230	0.220
VIT-C	(MG)	7.000	5.000	4.000	2.000	4.000
PANTO	(UG)	500.000	500.000	500.000	100.000	500.000
BIOTIN	(MG)	1.000	2.000	5.000	2.000	8.000
VIT-A	(IU)	980.000	60.000	110.000	60.000	590.000
VIT-D	(IU)	0.0	0.0	0.0	0.0	0.0
VIT-E	(MG)	0.300	0.0	1.200	0.200	0.200
CA	(MG)	12.000	18.000	23.000	32.000	41.000
P	(MG)	75.000	34.000	117.000	126.000	145.000
MG	(MG)	20.000	18.000	18.000	26.000	19.000
FE	(MG)	1.200	0.500	1.000	1.700	1.200
I	(MG)	3.000	3.000	4.000	5.000	5.000
ZN	(MG)	1.000	0.500	1.900	1.800	2.500
NA	(MG)	37.000	290.000	287.000	531.000	344.000
K	(MG)	250.000	167.000	189.000	233.000	112.000
CU	(MG)	0.020	0.110	0.190	0.330	0.220

ITEM CLUSTER		211	212	213	214	215
ATTRIBUTE GROUP		57	58	59	60	61
NUTRIENTS:						
KCAL		131.000	112.000	181.000	215.000	245.000
PROT	(GM)	8.000	8.400	8.800	8.400	9.500
TRY	(MG)	80.000	100.000	100.000	170.000	160.000
THR	(MG)	250.000	500.000	390.000	520.000	400.000
ISO	(MG)	460.000	630.000	460.000	750.000	690.000
LEU	(MG)	580.000	920.000	720.000	1110.000	1090.000
LYS	(MG)	460.000	1090.000	780.000	730.000	590.000
MET	(MG)	140.000	330.000	220.000	280.000	240.000
CYS	(MG)	110.000	170.000	110.000	170.000	160.000
PHE	(MG)	330.000	340.000	360.000	440.000	490.000
TYR	(MG)	250.000	130.000	300.000	560.000	520.000
VAL	(MG)	370.000	590.000	490.000	860.000	700.000
HIS	(MG)	680.000	320.000	310.000	370.000	330.000
FAT-T	(GM)	6.700	3.000	11.300	11.100	7.100
SFA	(GM)	3.000	1.000	5.000	5.000	2.000
PUFA	(GM)	3.000	1.000	5.000	6.000	3.000
CHOLE	(GM)	0.020	0.020	0.020	0.040	0.040
CHO-T	(GM)	9.800	12.700	10.700	20.100	35.400
SUCR	(GM)	1.400	1.200	0.100	0.100	3.900
CHO-F	(GM)	0.300	0.300	0.500	0.100	0.300
THIA	(MG)	0.100	0.070	0.010	0.100	0.060
RIBO	(MG)	0.140	0.090	0.090	0.200	0.170
NIACIN	(MG)	1.700	2.300	2.100	0.900	1.000
VIT-B6	(MG)	230.000	250.000	80.000	40.000	50.000
FOLIC	(UG)	7.000	10.000	9.000	6.000	3.000
VIT-B12	(UG)	0.360	0.210	0.920	0.350	0.200
VIT-C	(MG)	4.000	4.000	10.000	0.0	6.000
PANTO	(UG)	300.000	600.000	500.000	200.000	300.000
BIOTIN	(MG)	2.000	4.000	2.000	2.000	1.000
VIT-A	(IU)	430.000	130.000	10.000	430.000	440.000
VIT-D	(IU)	0.0	0.0	0.0	20.000	8.000
VIT-E	(MG)	0.200	0.200	0.100	0.500	0.300
CA	(MG)	19.000	26.000	13.000	181.000	156.000
P	(MG)	117.000	87.000	67.000	161.000	156.000
MG	(MG)	19.000	21.000	19.000	26.000	27.000
FE	(MG)	1.300	1.100	2.000	0.900	0.900
I	(MG)	4.000	3.000	4.000	5.000	9.000
ZN	(MG)	1.900	1.200	1.200	0.300	1.100
NA	(MG)	393.000	400.000	540.000	543.000	647.000
K	(MG)	115.000	176.000	200.000	120.000	114.000
CU	(MG)	0.170	0.140	0.140	0.040	0.340

ITEM CLUSTER		216	217	218	219	220
ATTRIBUTE GROUP		62	63	64	65	66
NUTRIENTS:						
KCAL		76.000	134.000	140.000	120.000	0.0
PROT	(GM)	2.200	7.500	4.500	20.000	0.0
TRY	(MG)	30.000	80.000	70.000	230.000	0.0
THR	(MG)	90.000	300.000	120.000	880.000	0.0
ISO	(MG)	110.000	350.000	150.000	1040.000	0.0
LEU	(MG)	150.000	530.000	230.000	1630.000	0.0
LYS	(MG)	70.000	520.000	240.000	1740.000	0.0
MET	(MG)	30.000	160.000	70.000	490.000	0.0
CYS	(MG)	40.000	100.000	40.000	250.000	0.0
PHE	(MG)	110.000	310.000	130.000	340.000	0.0
TYR	(MG)	70.000	220.000	100.000	680.000	0.0
VAL	(MG)	130.000	350.000	150.000	1110.000	0.0
HIS	(MG)	50.000	220.000	100.000	690.000	0.0
FAT-T	(GM)	0.600	4.700	7.100	3.000	0.0
SFA	(GM)	0.0	2.000	3.000	1.000	0.0
PUFA	(GM)	0.0	3.000	3.000	1.000	0.0
CHOLE	(GM)	0.006	0.020	0.009	0.002	0.0
CHO-T	(GM)	15.400	15.600	14.200	5.000	0.0
SUCR	(GM)	5.500	4.200	0.0	0.0	0.0
CHO-F	(GM)	0.200	0.300	0.0	1.100	0.0
THIA	(MG)	0.140	0.100	0.0	0.010	0.0
RIBO	(MG)	0.110	0.120	0.0	0.230	0.0
NIACIN	(MG)	1.800	1.600	0.0	11.400	0.0
VIT-B6	(MG)	50.000	150.000	200.000	0.0	0.0
FOLIC	(UG)	1.000	6.000	1.000	0.0	0.0
VIT-B12	(UG)	0.250	0.220	0.0	0.0	0.0
VIT-C	(MG)	4.000	9.000	0.0	0.0	0.0
PANTO	(UG)	300.000	200.000	400.000	0.0	0.0
BIOTIN	(MG)	0.0	1.000	10.000	0.0	0.0
VIT-A	(IU)	370.000	640.000	0.0	0.0	0.0
VIT-D	(IU)	1.000	0.0	0.0	0.0	0.0
VIT-E	(MG)	0.400	0.300	0.100	0.100	0.0
CA	(MG)	16.000	50.000	20.000	0.0	253.000
P	(MG)	35.000	95.000	39.000	297.000	200.000
MG	(MG)	11.000	17.000	9.000	57.000	190.000
FE	(MG)	1.100	1.500	1.200	4.600	0.100
I	(MG)	5.000	3.000	3.000	43.000	10000.000
ZN	(MG)	0.100	1.400	0.900	0.800	0.500
NA	(MG)	382.000	407.000	665.000	2400.000	38758.000
K	(MG)	121.000	268.000	0.0	100.000	4.000
CU	(MG)	0.120	0.170	0.050	0.090	0.380

ITEM CLUSTER 221
ATTRIBUTE GROUP 67
NUTRIENTS:

KCAL		392.000
PROT	(GM)	9.400
TRY	(MG)	40.000
THR	(MG)	110.000
ISO	(MG)	150.000
LEU	(MG)	300.000
LYS	(MG)	160.000
MET	(MG)	20.000
CYS	(MG)	100.000
PHE	(MG)	200.000
TYR	(MG)	110.000
VAL	(MG)	190.000
HIS	(MG)	50.000
FAT-T	(GM)	10.600
SFA	(GM)	6.000
PUFA	(GM)	4.000
CHOLE	(GM)	0.0
CHO-T	(GM)	73.900
SUCR	(GM)	72.000
CHO-F	(GM)	0.800
THIA	(MG)	0.080
RIBO	(MG)	0.410
NIACIN	(MG)	0.500
VIT-B6	(MG)	20.000
FOLIC	(UG)	80.000
VIT-B12	(UG)	0.0
VIT-C	(MG)	1.000
PANTO	(UG)	100.000
BIOTIN	(MG)	32.000
VIT-A	(IU)	10.000
VIT-D	(IU)	1060.000
VIT-E	(MG)	0.400
CA	(MG)	275.000
P	(MG)	290.000
MG	(MG)	371.000
FE	(MG)	1.400
I	(MG)	8.000
ZN	(MG)	2.600
NA	(MG)	382.000
K	(MG)	605.000
CU	(MG)	3.690

APPENDIX D

ABRIDGED FOOD-COMPOSITION FILE

Listing of 22 nutrients selected from the food-composition file (Appendix C) for each of the 127 item clusters designated in Appendix B.

ENERGY (kcal)
PROTEIN (gm)
TOTAL FAT (gm)
SATURATED FAT (gm)
POLYUNSATURATED FAT (gm)
TOTAL CARBOHYDRATE (gm)
SUCROSE (gm)
FIBER (gm)
THIAMIN (mg)
RIBOFLAVIN (mg)
NIACIN (mg)
PYRODOXINE (ug)
FOLACIN (ug)
ASCORBATE (mg)
RETINOL (iu)
CHOLECALCIFEROL (iu)
TOCOPHEROL (mg)
CALCIUM (mg)
PHOSPHORUS (mg)
MAGNESIUM (mg)
IRON (mg)
POTASSIUM (mg)

APPENDIX E

NUTRIENT-LIMITS FILE

Tables of daily minimum (Table E-1) and daily maximum (Table E-2) nutrient limits disaggregated for age, sex, activity pattern, and pregnancy status.

Table E-1. Minimum nutrient limits

Code #	Sex	Age	Activity Pattern	Energy[ab] kcal/kg[c]/day	Protein[aef] gm/kg/day	Histidine[fh] mg/kg/day	Isoleucine[fi] mg/kg/day
111	Male	19-35	A	42.6	.57	.10	.10
112			B	40.6			
113			C	35.7			
114			D	32.6			
121		36-50	A	41.4			
122			B	39.3			
123			C	34.4			
124			D	31.3			
131		51-65	A	40.2			
132			B	38.0			
133			C	33.3			
134			D	30.1			
141		66 +	A	38.9			
142			B	36.9			
143			C	32.0			
144			D	28.6			
211	Female	19-35	A	37.3	.52		
212			B	35.2			
213			C	33.8			
214			D	30.7			
221			A	36.3			
222			B	34.1			
223			C	32.7			
224			D	29.6			
231		51-65	A	35.0			
232			B	32.9			
233			C	31.4			
234			D	28.4			
241			A	33.9			
242		66 +	B	31.8			
243			C	30.4			
244			D	27.3			
205		Preg.[d] 1st	+	100 kcal/day	+ 20 gm/day		
206		Preg. 2nd + 3rd	+	100 kcal/day	+ 20 gm/day		
207		Lact.	+	500 kcal/day	+ 24 gm/day		

[a] Values for minimum limit (and for recommended energy intake) are obtained from: Bureau of Nutritional Sciences, Department of National Health and Welfare. Dietary Standard for Canada. Information Canada, Ottawa, 1975.

[b] To calculate lower and upper limit on energy intake per day for an individual, the recommended intake for a given age, sex, and activity level is multiplied by kilograms ideal body weight, then, the multiplied figure is summed with the additional caloric requirements for pregnancy or lactation, and lastly, this figure is reduced or raised five percent. For longer period of time, the daily limits are multiplied by the number of days considered.

[c] Body weight is measured as kilograms ideal body weight.

Table E-1. Minimum nutrient limits (cont'd)

Code #	Leucine[fi] mg/kg/day	Lysine[fi] mg/kg/day	Methionine[fi] + Cystine mg/kg/day	Phenylalanine[fi] + Tyrosine mg/kg/day	Threonine[fi] mg/kg/day
111	14	12	13	14	7
112					
113					
114					
121					
122					
123					
124					
131					
132					
133					
134					
141					
142					
143					
144					
211					
212					
213					
214					
221					
222					
223					
224					
231					
232					
233					
234					
241					
242					
243					
244					
205					
206					
207	↓	↓	↓	↓	↓

[d] Where increased minimum allowance associated with pregnancy and lactation is not stated, the increase, if any, is calculated on the basis of increased body weight or caloric requirement. Maximum intake limits for pregnant and lactating females are the same as for non-pregnant females.

[e] Minimum protein limit for the abridged nutrient consumption file (Appendix F) is 0.80 gm/kg/day for males, and 0.73 gm/kg/day for females. This figure is based on the average amino acid composition of the Canadian diet as stated in the Dietary Standard For Canada, Bureau of Nutritional Sciences, Department of National Health and Welfare, Information Canada, Ottawa, 1975.

Table E-1. Minimum nutrient limits (cont'd)

Code #	Tryptophan[fi] mg/kg/day	Valine[fi] mg/kg/day	Fat[aj] %kcal/day	Saturated[aj] Fat %kcal/day	P/S[k] Ratio	Polyunsat.[aj] Fat %kcal/day
111	3.5	10	2	0	1	2
112	↓	↓	↓	↓	↓	↓
113	↓	↓	↓	↓	↓	↓
114	↓	↓	↓	↓	↓	↓
121	↓	↓	↓	↓	↓	↓
122	↓	↓	↓	↓	↓	↓
123	↓	↓	↓	↓	↓	↓
124	↓	↓	↓	↓	↓	↓
131	↓	↓	↓	↓	↓	↓
132	↓	↓	↓	↓	↓	↓
133	↓	↓	↓	↓	↓	↓
134	↓	↓	↓	↓	↓	↓
141	↓	↓	↓	↓	↓	↓
142	↓	↓	↓	↓	↓	↓
143	↓	↓	↓	↓	↓	↓
144	↓	↓	↓	↓	↓	↓
211	↓	↓	↓	↓	↓	↓
212	↓	↓	↓	↓	↓	↓
213	↓	↓	↓	↓	↓	↓
214	↓	↓	↓	↓	↓	↓
221	↓	↓	↓	↓	↓	↓
222	↓	↓	↓	↓	↓	↓
223	↓	↓	↓	↓	↓	↓
224	↓	↓	↓	↓	↓	↓
231	↓	↓	↓	↓	↓	↓
232	↓	↓	↓	↓	↓	↓
233	↓	↓	↓	↓	↓	↓
234	↓	↓	↓	↓	↓	↓
241	↓	↓	↓	↓	↓	↓
242	↓	↓	↓	↓	↓	↓
243	↓	↓	↓	↓	↓	↓
244	↓	↓	↓	↓	↓	↓
205	↓	↓	↓	↓	↓	↓
206	↓	↓	↓	↓	↓	↓
207	↓	↓	↓	↓	↓	↓

[f] For determining limits on intake per day, multiply the table value by the individual's ideal body weight in kilograms.

[g] Additional minimum protein requirement for pregnancy and lactation based on the composition of the average daily protein intake of Canadians as per the Dietary Standard for Canada, Bureau of Nutritional Sciences, Department of National Health and Welfare, Information Canada, Ottawa, 1975.

[h] Value for minimum limit on histidine obtained from: personal communication, Dr. P.J. Stapleton, 1978.

[i] Values for minimum limit obtained from: FAO/WHO, Ad Hoc Expert Committee. Energy and Protein Requirements. WHO Tech. Rep. Ser. No. 522, Geneva, 1973.

Table E-1. Minimum nutrient limits (cont'd)

Code #	Cholesterol[a] mg/day	Carbo-[jl] hydrate % kcal/day	Sucrose[jm] % kcal/day	Fiber[no] gm/100 kcal/day	Thiamin[ao] mg/1000 kcal/day	Niacin[aop] NE/1000 kcal/day
111	0	55	0	0.4	0.5	6.6
112						
113						
114						
121						
122						
123						
124						
131						
132						
133						
134						
141						
142						
143						
144						
211						
212						
213						
214						
221						
222						
223						
224						
231						
232						
233						
234						
241						
242						
243						
244						
205					↓	↓
206					+0.2 mg/day	+2 NE/day
207	↓	↓	↓	↓	+0.4 mg/day	+7 NE/day

j To convert %kcal/day to gm or mg/day, use the average caloric intake for an individual of given age, sex, weight, activity level, and pregnancy status; and the conversion value of 9kcal/gm for fat, or 4kcal/gm for carbohydrate.

k Value for limit obtained from: American Heart Association. Diet and Coronary Heart Disease. 1973.

l Value for limit obtained from: Select Committee on Nutrition and Human Needs, U.S. Senate. Dietary Goals for the United States. Government Printing Office, Washington, D.C., 1977.

Table E-1. Minimum nutrient limits (cont'd)

Code #	Riboflavin[ao] mg/1000 kcal/day	Vit-B6[aq] mg/day	Folacin[a] ug/day	Vit-B12[a] ug/day	Vit-C[aq] mg/day	Panto-[a] thenate mg/day	Biotin[a] ug/day
111	.6	2.0	200	3.0	30	5.0	40
112							
113							
114							
121							
122							
123							
124							
131							
132							
133							
134							
141							
142							
143							
144							
211		1.5					
212							
213							
214							
221							
222							
223							
224							
231							
232							
233							
234							
241							
242							
243							
244							
205		+ 0.5 mg	+ 50 ug	+ 1.0 ug	+ 20 mg		
206	+ 0.3 mg/day	+ 0.5 mg	+ 50 ug	+ 1.0 ug	+ 20 mg		
207	+ 0.6 mg/day	+ 0.6 mg	+ 50 ug	+ 0.5 ug	+ 20 mg		

m Value for minimum limit on sucrose obtained from: Food and Nutrition Board, NRC/NAS, Recommended Dietary Allowances, 1974.

n Value for limit obtained from: Cheney, M.C. Food Enrichment: Nutritional Standard for Synthetic and Modified Foods. Paper presented at Current Topics in Food and Nutrition - Workshop. University of British Columbia, Vancouver, B.C., July 27, 1976.

o Average caloric intake per day for an individual of given sex, age, size, activity level, and pregnancy status is used for conversion of table value to gm/day, mg/day, or NE/day.

p Potential niacin equivalents derived from conversion of excess tryptophan have not been considered in evaluation of niacin intake.

Table E-1. Minimum nutrient limits (cont'd)

Code #	Vit-A[r] iu/day	Vit-D[a] [s] iu/day	Vit-E[a] mg/day	Calcium[a] mg/day	Phosphorus[a] mg/day	Ca/P[t] Ratio	Magnesium [a] mg/dg/day
111	5000	100	9	800	800	.8	4.5
112							
113							
114							
121			8				
122							
123							
124							
131							
132							
133							
134							
141							
142							
143							
144							
211	4000		6	700	700		
212							
213							
214							
211							
222							
223							
224							
231							
232							
233							
234							
241							
242							
243							
244							
205		+100 iu	+1.0 mg	+500 mg	+500 mg		+25 mg/day
206	+1000 iu	+100 iu	+1.0 mg	+500 mg	+500 mg		+25 mg/day
207	+2000 iu	+100 iu	+2.0 mg	+500 mg	+500 mg		+75 mg/day

[q] The increased requirement for pyridoxine and vitamin-C with the consumption of birth control pills has not been considered in determining the minimum limit. A tenfold increase in requirement has been suggested in the Dietary Standard for Canada. Bureau of Nutritional Sciences, Department of National Health and Welfare, Information Canada, Ottawa, 1975.

[r] Value for limit obtained from: Food and Nutrition Board, National Research Council. Recommended Dietary Allowances, 8th edition. National Academy of Sciences, Washington, D.C., 1974.

[s] Minimum vitamin-D allowance should be increased 100 iu/day for those individuals confined indoors or otherwise deprived of sunlight for long period of time, except pregnant and lactating females whose recommendation has already been increased to 200 iu.

Table E-1. Minimum nutrient limits (cont'd)

Code #	Iodine[ao] ug/1000 kcal/day	Iron[a] mg/day	Zinc[a] mg/day	Sodium[afu] mg/kg/day	Potassium[afu] mg/kg/day	Copper[a] mg/day
111	50	10	10	6	20	2.0
112	↓	↓	↓	↓	↓	↓
113	↓	↓	↓	↓	↓	↓
114	↓	↓	↓	↓	↓	↓
121	↓	↓	↓	↓	↓	↓
122	↓	↓	↓	↓	↓	↓
123	↓	↓	↓	↓	↓	↓
124	↓	↓	↓	↓	↓	↓
131	↓	↓	↓	↓	↓	↓
132	↓	↓	↓	↓	↓	↓
133	↓	↓	↓	↓	↓	↓
134	↓	↓	↓	↓	↓	↓
141	↓	↓	↓	↓	↓	↓
142	↓	↓	↓	↓	↓	↓
143	↓	↓	↓	↓	↓	↓
144	↓	↓	↓	↓	↓	↓
211	↓	14	9	↓	↓	↓
212	↓	↓	↓	↓	↓	↓
213	↓	↓	↓	↓	↓	↓
214	↓	↓	↓	↓	↓	↓
221	↓	↓	↓	↓	↓	↓
222	↓	↓	↓	↓	↓	↓
223	↓	↓	↓	↓	↓	↓
224	↓	↓	↓	↓	↓	↓
231	↓	9	↓	↓	↓	↓
232	↓	↓	↓	↓	↓	↓
233	↓	↓	↓	↓	↓	↓
234	↓	↓	↓	↓	↓	↓
241	↓	↓	↓	↓	↓	↓
242	↓	↓	↓	↓	↓	↓
243	↓	↓	↓	↓	↓	↓
244	↓	↓	↓	↓	↓	↓
205	+15 mg/day	+1 mg	+3 mg	+164 mg/day	+280 mg/day	↓
206	+15 mg/day	+1 mg	+3 mg	+164 mg/day	+280 mg/day	↓
207	+25 ug/day	+1 mg	+7 mg	+864 mg/day	+1480 mg/day	↓

[t] Values for limits on Ca/P ratio arbitrarily assigned for test purposes.

[u] Minimum maintenance level has been used for establishing the minimum sodium and potassium limit as per the Dietary Standard for Canada. Bureau of Nutritional Sciences, Department of National Health and Welfare, Information Canada, Ottawa, 1975.

[v] Value for the maximum limit arbitrarily assigned at twice the minimum limit in the absence of empirical values. This was done for test purposes and does not imply that these values represent empirical values.

Table E-2. Maximum nutrient limits

Code #	Sex	Age	Activity Pattern	Energy[ab] kcal/kg[c]/day	Protein[fu] gm/kg/day	Histidine[fw] mg/kg/day
111	Male	19-35	A	42.6	1.14	1057
112			B	40.6		
113			C	35.7		
114			D	32.6		
121		36-50	A	41.4		
122			B	39.3		
123			C	34.4		
124			D	31.3		
131		51-65	A	40.2		
132			B	38.0		
133			C	33.3		
134			D	30.1		
141		66 +	A	38.9		
142			B	36.9		
143			C	32.0		
144			D	28.6		
211	Female	19-35	A	37.3	1.04	957
212			B	35.2		
213			C	33.8		
214			D	30.7		
221		36-50	A	36.3		
222			B	34.1		
223			C	32.7		
224			D	29.6		
231		51-65	A	35.0		
232			B	32.9		
233			C	31.4		
234			D	28.4		
241		66 +	A	33.9		
242			B	31.8		
243			C	30.4		
244			A	27.3		
205		Preg.[d] 1st				
206		Preg. 2nd+3rd				
207		Lact.				

[w] The maximum limit for amino acids is the amount of any one amino acid that could be attained in excess of the minimum requirement for all other amino acids without exceeding the maximum protein intake limit.

[x] The maximum limit on polyunsaturate fat equals the upper limit on total fat intake.

[y] The maximum limit on cholesterol intake is arbitrarily set at twice the American Health Association recommended upper level of cholesterol intake.

[z] The maximum limit on total carbohydrate intake allows 10% of energy expenditure for minimum protein requirement and minimum fat requirement.

* Value for maximum limit of vitamin-C intake arbitrarily assigned for test purposes.

Table E-2. Maximum nutrient limits (Cont'd)

Code #	Isoleucine[fw] mg/kg/day	Leucine[fw] mg/kg/day	Lysine[fw] mg/kg/day	Methionine[fw] + Cystine mg/kg/day	Phenylalanine[fw] + Tyrosine mg/kg/day
111	1057	1061	1059	1060	1061
112					
113					
114					
121					
122					
123					
124					
131					
132					
133					
134					
141					
142					
143					
144					
211	957	961	959	960	961
212					
213					
214					
221					
222					
223					
224					
231					
232					
233					
234					
241					
242					
243					
244					
205					
206					
207					

+ Values for maximum limits of vitamin-D and vitamin-A intake arbitrarily assigned for test purposes.

Determination of the maximum limit of vitamin-A does not consider non-toxicity of the provitamin forms.

++ Value for maximum limit of vitamin-E intake arbitrarily assigned for test purposes.

+++ The maximum limit on sodium intake is extrapolated from the suggested maximum sodium intake per day of 3 grams, obtained from the Select Committee on Nutrition and Human Needs, U.S. Senate. Dietary Goals for the United States. Government Printing Office, Washington, D.C., 1977. The goal of $\leq$ 3 gm/day is transformed to mg/kg/day on the basis of a reference individual of 60 kg.

Table E-2. Maximum nutrient limits (cont'd)

Code #	Threonine[fw] mg/kg/day	Tryptophan[fw] mg/kg/day	Valine[fw] mg/kg/day	Fat[jk] %kcal/day	Saturated[jk] Fat %kcal/day	P/S[v] Ratio
111	1054	1050	1057	30	10	2
112	↓	↓	↓	↓	↓	↓
113	↓	↓	↓	↓	↓	↓
114	↓	↓	↓	↓	↓	↓
121	↓	↓	↓	↓	↓	↓
122	↓	↓	↓	↓	↓	↓
123	↓	↓	↓	↓	↓	↓
124	↓	↓	↓	↓	↓	↓
131	↓	↓	↓	↓	↓	↓
132	↓	↓	↓	↓	↓	↓
133	↓	↓	↓	↓	↓	↓
134	↓	↓	↓	↓	↓	↓
141	↓	↓	↓	↓	↓	↓
142	↓	↓	↓	↓	↓	↓
143	↓	↓	↓	↓	↓	↓
144	↓	↓	↓	↓	↓	↓
211	954	950	957	↓	↓	↓
212	↓	↓	↓	↓	↓	↓
213	↓	↓	↓	↓	↓	↓
214	↓	↓	↓	↓	↓	↓
221	↓	↓	↓	↓	↓	↓
222	↓	↓	↓	↓	↓	↓
223	↓	↓	↓	↓	↓	↓
224	↓	↓	↓	↓	↓	↓
231	↓	↓	↓	↓	↓	↓
232	↓	↓	↓	↓	↓	↓
233	↓	↓	↓	↓	↓	↓
234	↓	↓	↓	↓	↓	↓
241	↓	↓	↓	↓	↓	↓
242	↓	↓	↓	↓	↓	↓
243	↓	↓	↓	↓	↓	↓
244	↓	↓	↓	↓	↓	↓
205	↓	↓	↓	↓	↓	↓
206	↓	↓	↓	↓	↓	↓
207	↓	↓	↓	↓	↓	↓

Table E-2. Maximum nutrient limits (cont'd)

Code #	Polyunsat. Fat[jx] %kcal/day	Cholesterol[y] mg/day	Carbo-hydrate[jz] %kcal/day	Sucrose[jl] %kcal/day	Fiber[ov] gm/100 kcal/day	Thiamin[ov] mg/1000 kcal/day
111	30	600	90	15	0.8	1.0
112						
113						
114						
121						
122						
123						
124						
131						
132						
133						
134						
141						
142						
143						
144						
211						
212						
123						
214						
221						
222						
223						
224						
231						
232						
233						
234						
241						
242						
243						
244						
205						
206						
207	↓	↓	↓	↓	↓	↓

Table E-2. Maximum nutrient limits (cont'd)

Code #	Niacin[OV] NE/1000 kcal/day	Riboflavin[OV] mg/1000 kcal/day	Vit-B6[V] mg/day	Folacin[V] ug/day	Vit-B12[V] ug/day	Vit-C* mg/day	Panto-[V] thenate mg/day
111	13.2	1.2	4.0	400	6.0	500	10.0
112	↓	↓	↓	↓	↓	↓	↓
113	↓	↓	↓	↓	↓	↓	↓
114	↓	↓	↓	↓	↓	↓	↓
121	↓	↓	↓	↓	↓	↓	↓
122	↓	↓	↓	↓	↓	↓	↓
123	↓	↓	↓	↓	↓	↓	↓
124	↓	↓	↓	↓	↓	↓	↓
131	↓	↓	↓	↓	↓	↓	↓
132	↓	↓	↓	↓	↓	↓	↓
133	↓	↓	↓	↓	↓	↓	↓
134	↓	↓	↓	↓	↓	↓	↓
141	↓	↓	↓	↓	↓	↓	↓
142	↓	↓	↓	↓	↓	↓	↓
143	↓	↓	↓	↓	↓	↓	↓
144	↓	↓	↓	↓	↓	↓	↓
211	↓	↓	↓	↓	↓	↓	↓
212	↓	↓	↓	↓	↓	↓	↓
213	↓	↓	↓	↓	↓	↓	↓
214	↓	↓	↓	↓	↓	↓	↓
221	↓	↓	↓	↓	↓	↓	↓
222	↓	↓	↓	↓	↓	↓	↓
223	↓	↓	↓	↓	↓	↓	↓
224	↓	↓	↓	↓	↓	↓	↓
231	↓	↓	↓	↓	↓	↓	↓
232	↓	↓	↓	↓	↓	↓	↓
233	↓	↓	↓	↓	↓	↓	↓
234	↓	↓	↓	↓	↓	↓	↓
241	↓	↓	↓	↓	↓	↓	↓
242	↓	↓	↓	↓	↓	↓	↓
243	↓	↓	↓	↓	↓	↓	↓
244	↓	↓	↓	↓	↓	↓	↓
205	↓	↓	↓	↓	↓	↓	↓
206	↓	↓	↓	↓	↓	↓	↓
207	↓	↓	↓	↓	↓	↓	↓

Table E-2. Maximum nutrient limits (cont'd)

Code #	Biotin[v] ug/day	Vit-A[+] iu/day	Vit-D[+] iu/day	Vit-E[++] mg/day	Calcium[v] mg/day	Phosphorus[v] mg/day	Ca/P[t] Ratio
111	80	20000	600	1600	1600	1600	1.2
112	↓	↓	↓	↓	↓	↓	↓
113							
114							
212							
122							
123							
124							
131							
132							
133							
134							
141							
142							
143							
144							
211					1400	1400	
212					↓	↓	
213							
214							
221							
222							
223							
224							
231							
232							
233							
234							
241							
242							
243							
244							
205							
206							
207							

Table #-2. Maximum nutirent limits (cont'd)

Code #	Magnesium[V] mg/kg/day	Iodine[V] ug/1000 kcal/day	Iron[V] mg/day	Zinc[V] mg/day	Sodium[+++] mg/kg/day	Potassium[V] mg/kg/day	Copper[V] mg/day
111	9.0	100	20	20	50	40	4.0
112							
113							
114							
121							
122							
123							
124							
131							
132							
133							
134							
141							
142							
143							
144			↓				
211			28				
212							
213							
214							
221							
222							
223							
224							
231							
232							
233							
234							
241							
242							
243							
244							
205							
206							
207	↓	↓	↓	↓	↓	↓	↓

APPENDIX F

ABRIDGED NUTRIENT-LIMITS FILE

Listing of 48 maximum and minimum nutrient limits selected from the nutrient-limits file (Appendix E) to coordinate with the abridged food-composition file (Appendix D) and the abridged food-item file (Appendix B).

MINIMUM*	MAXIMUM*
ENERGY	ENERGY
PROTEIN	PROTEIN
TOTAL FAT	TOTAL FAT
SATURATED FAT	SATURATED FAT
POLYUNSATURATED FAT	POLYUNSATURATED FAT
P/S RATIO	P/S RATIO
TOTAL CARBOHYDRATE	TOTAL CARBOHYDRATE
SUCROSE	SUCROSE
FIBER	FIBER
THIAMIN	THIAMIN
RIBOFLAVIN	RIBOFLAVIN
NIACIN	NIACIN
PYRIDOXINE	PYRIDOXINE
FOLATE	FOLATE
ASCORBATE	ASCORBATE
RETINOL	RETINOL
CHOLECALCIFEROL	CHOLECALCIFEROL
TOCOPHEROL	TOCOPHEROL
CALCIUM	CALCIUM
PHOSPHORUS	PHOSPHORUS
CA/P RATIO	CA/P RATIO
MAGNESIUM	MAGNESIUM
IRON	IRON
POTASSIUM	POTASSIUM

* see Appendix E for the values associated with each of these nutrient limits.

APPRENDIX G

ATTRIBUTE-GROUP MATRIX

Table of attribute group assignments for 221 item clusters.

Item Cluster Code #[a]	Attrib. Group Code #	k - 1[b] $J_1 = 67$[c]	k = 2 $J_2 = 55$	k = 3 $J_3 = 52$	k = 4 $J_4 = 38$	k = 5 $J_5 = 35$	k = 6 $J_6 = 27$	k = 7 $J_7 = 4$
001-005	001		cheese		dairy	dairy-eggs		non-sweet solid
006-009	002		cultured milk					
010-011	003				eggs			
012-013	004	ready-to-eat	cereal	breakfast	grain			
014-016	005	cooked						
017	006		pancake-waffle					
018-019	007		pastas	dinner				
020-023	008		other cereal					
024-030	009	bread	bread-rolls	other meal				
031-035	010	rolls						
036-040	011		crackers					
041-048	012	mammal	carcass meat		meat	protein foods		
049-052	013	poultry						
053-066	014	fish						
067	015	liver	organ meat					
068	016	other organ						
069-071	017		variety meat					
072-075	018		peas-beans		plant protein			
076-081	019		nuts					
082-087	020	potatoe	vegetables		vegetable			
088-102	021	greens						
103-112	022	yellow-red						
113-115	023	other color						
116	024	mixed						
117-119	025		veg. products					
120-124	026		cooking fats		fats and oils			
125-126	027		table fats					
127-131	028		sauces					
132-135	029		salad dressing					
136-138	030	fresh fluid	milk		dairy		beverages	fluid
139-142	031	cream						
143-149	032				fruit	fruit-vegie		
150	033				vegetable			
151-152	034				misc.-sugar			
153-154	035				misc.-tea			
155-158	036				misc.-alcohol			

Item[a] Cluster Code #	Attrib. Group Code #	k = 1[b] $J_1 = 67$[c]	k = 2 $J_2 = 55$	k = 3 $J_3 = 52$	k = 4 $J_4 = 38$	k = 5 $J_5 = 35$	k = 6 $J_6 = 27$	k = 7 $J_7 = 4$
159-164	037						soups	
165-170	038	cakes	cakes-pies		grain		desserts	sweet solid
171-172	039	pies						
173-174	040	cookies	cookies-other					
175-177	041	other pastry						
178-180	042		frozen		dairy			
181-182	043		non-frozen					
183-192	044		not dried		fruit			
193	045		dried					
194	046		simulated					
195-197	047		sweeteners				sweets	
198-199	048		spreads					
200-203	049		candies					
204	050							miscellaneous
205	051							
206	052							
207	053							
208	054							
209	055							
210	056							
211	057							
212	058							
213	059							
214	060							
215	061							
216	062							
217	063							
218	064							
219	065							
220	066							
221	067							

[a] The abridged attribute-group matrix which corresponds to the abridged food-item file (Appendix B) is derived from Appendix G.

[b] k equals the hierarchy level number.

[c] J_k equals the number of attribute classes in the hierarchy level.