17. Food as a source of nutrients

17.1 Importance of defining food-based recommendations

Dietary patterns have varied over time. Changes in these patterns are dependent on such things as agricultural practices and climatic, ecologic, cultural, and socioeconomic factors, which in turn, determine which foods are available. At present, virtually all dietary patterns show that the nutritional needs of population groups are adequately satisfied or even exceeded. This is true except where socioeconomic conditions limit the capacity to produce and purchase food or aberrant cultural practices restrict the choice of foods. It is thought that if people have access to a sufficient quantity and variety of foods, they will meet, in large part, their nutritional needs. However, for certain groups of people because of economic restrictions, levels of certain micronutrients may not be met from food alone. Thus, micronutrient adequacy must be included in evaluating the nutritive value of diets alongside energy and protein adequacy.

A healthful diet can be attained through the intake of multiple combinations of a variety of foods. Given this, it is difficult to define the ranges of intake for a specific food, which should be included in a given combination with other foods to comply with nutritional adequacy. In practice, the set of food combinations which provide nutritional adequacy are limited by the level of food production sustainable in a given ecological setting. In addition, there are economic constraints that limit food supply at the household level. The development of food-based dietary guidelines (FBDGs) (*1*) recognizes this and focuses on how a combination of foods can meet nutrient requirements rather than on how each specific nutrient is provided in adequate amounts.

The first step in the process of setting dietary guidelines is defining the significant diet-related public health problems in a community. Once these are defined, the adequacy of the diet is evaluated by comparing the information available on dietary intake with the established recommended nutrient intakes (RNIs). Nutrient intake goals are specific for a given setting, and their purpose is to promote overall health, control specific nutritional diseases (whether they are induced by an excess or deficiency of nutrient intake), and reduce the risk of diet-related multifactorial diseases. Dietary guidelines represent the practical way to reach the nutritional goals for a given population. They take into account customary dietary patterns and indicate what aspects of each should be modified. They consider the ecological setting in which the population lives, as well as the socioeconomic and cultural factors that affect nutritional adequacy.

The alternative approach to defining nutritional adequacy of diets relies on the biochemical and physiological basis of human nutritional requirements in health and disease. The quantitative definition of nutrient needs and its expression as RNIs have been important instruments of food and nutrition policy in many countries and have focused the attention of international bodies on this critical issue. This nutrient-based approach has served many purposes but has not always fostered the establishment of nutritional and dietary priorities consistent with the broad public health priorities at the national and international levels. It has permitted a more precise definition of requirements for essential nutrients but unfortunately has often been too narrowly focused, concentrating on the precise nutrient requirement amount, and not on solving the nutritional problems of the world.

In contrast to RNIs, FBDGs are based on the fact that people eat food, not nutrients. Defining nutrient intakes alone is only part of the task of dealing with nutritional adequacy. As will be illustrated in this chapter, the notion of nutrient density is helpful for defining FBDGs and evaluating the adequacy of diets. However, unlike RNIs, FBDGs can be used to educate the public through the mass media and provide a practical guide to selecting foods by defining dietary adequacy (*1*).

Advice for a healthful diet should provide both a quantitative and qualitative description of the diet for it to be understood by individuals, who should be given information on both size and number of servings per day. The quantitative aspects include the estimation of the amount of nutrients in foods and their bioavailability in the form they are actually consumed. Unfortunately, available food composition data for most foods currently consumed in the world are incomplete, outdated, or insufficient for evaluating true bioavailability. The qualitative aspects relate to the biological utilization of nutrients in the food as consumed by humans and explore the potential for interaction among nutrients. Such an interaction may enhance or inhibit the bioavailability of a nutrient from a given food source.

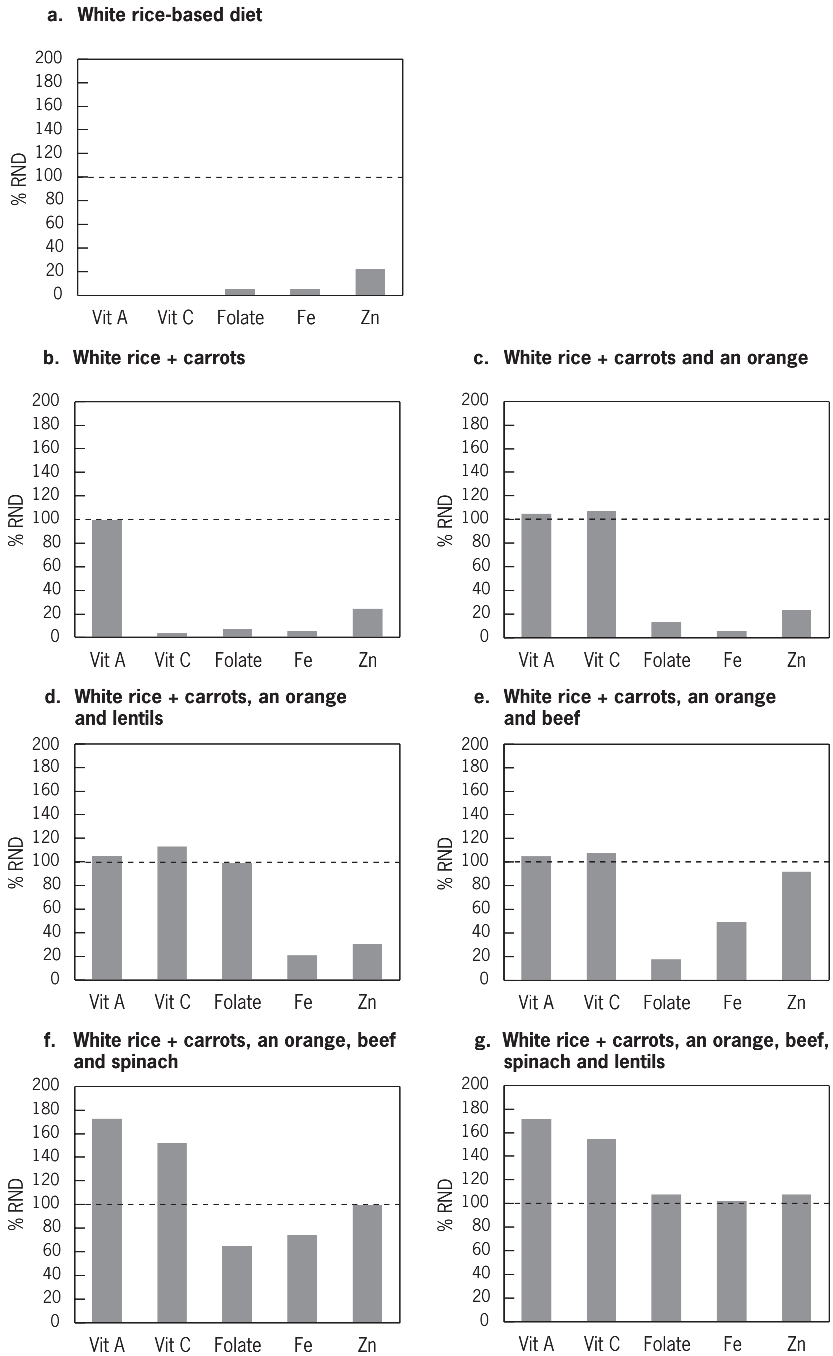
The inclusion of foods in the diet which have high micronutrient density—such as pulses or legumes, vegetables (including green leafy vegetables), and fruits—is the preferred way of ensuring optimal nutrition, including micronutrient adequacy, for most population groups. Most population groups who are deficient in micronutrients subsist largely on refined cereal grain- or tuber-based diets, which provide energy and protein (with an improper amino acid balance) but insufficient levels of critical micronutrients. There is a need for a broadening of the food base and a diversification of diets. Figures 17.1–17.4 illustrate how addition of a variety of foods to four basic diets (i.e. a white rice-based diet; a corn-tortilla-based diet; a refined couscous-based diet; and a potato-based diet) can increase the nutrient density of a cereal- or tuber-based diet. Adding reasonable amounts of these foods will add micronutrient density to the staple diet and in doing so could reduce the prevalence of diseases resulting from a micronutrient deficiency across populations groups.

The recent interest in the role of phytochemicals and antioxidants on health, and their presence in plant foods, lends further support to the recommendation for increasing the consumption of vegetables and fruit in the diet. The need for dietary diversification is supported by the knowledge of the interrelationships of food components, which may enhance the nutritional value of foods and prevent undesirable imbalances which may limit the utilization of some nutrients. For example, fruits rich in ascorbic acid will enhance the absorption of non-haem iron.

If energy intake is low (<8.368 MJ/day), for example, in the case of young children, sedentary women, or the elderly, the diet may not provide sufficient amounts of vitamins and minerals to meet RNIs. This situation may be of special relevance to the elderly, who are inactive, have decreased lean body mass, and typically decrease their energy intake. Young children, pregnant women, and lactating women who have greater micronutrient needs relative to their energy needs will also require an increased micronutrient density.

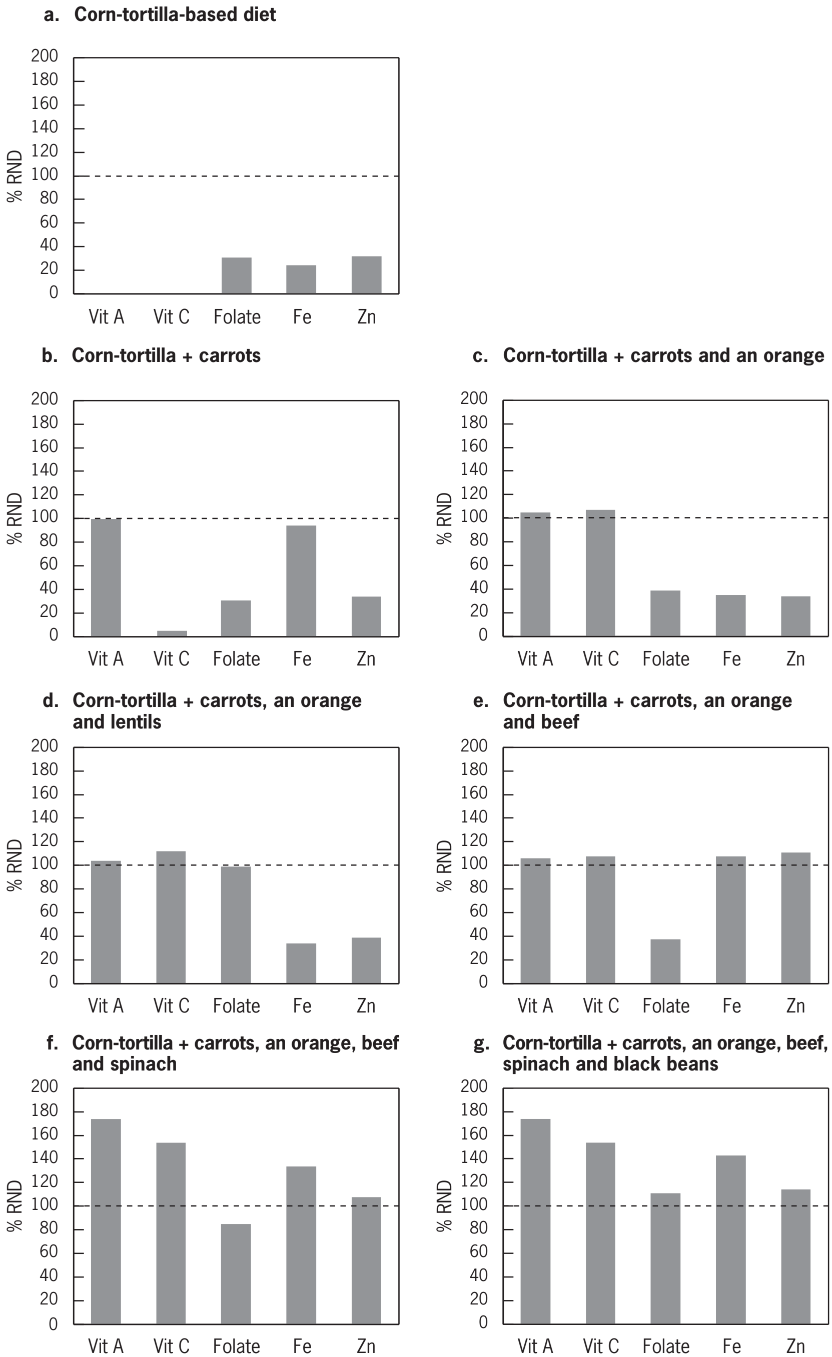
The household is the basic unit in which food is consumed in most settings. If there is sufficient food, individual members of the household can consume a diet with the recommended nutrient densities (RNDs) and meet their specific RNIs. However, appropriate food distribution within the family must be considered to ensure that children and women receive adequate food with high micronutrient density. Household food distribution must be considered when establishing general dietary guidelines and addressing the needs of vulnerable groups in the community. In addition, education detailing the appropriate storage and processing of foods to reduce micronutrient losses at the household level is important.

FIGURE 17.1
Impact of the addition of selected micronutrient-rich foods to a white rice-based diet on the recommended nutrient density (RND) of vitamin A, vitamin C, folate, iron (Fe) and zinc (Zn)



Source: adapted from reference (*2*).

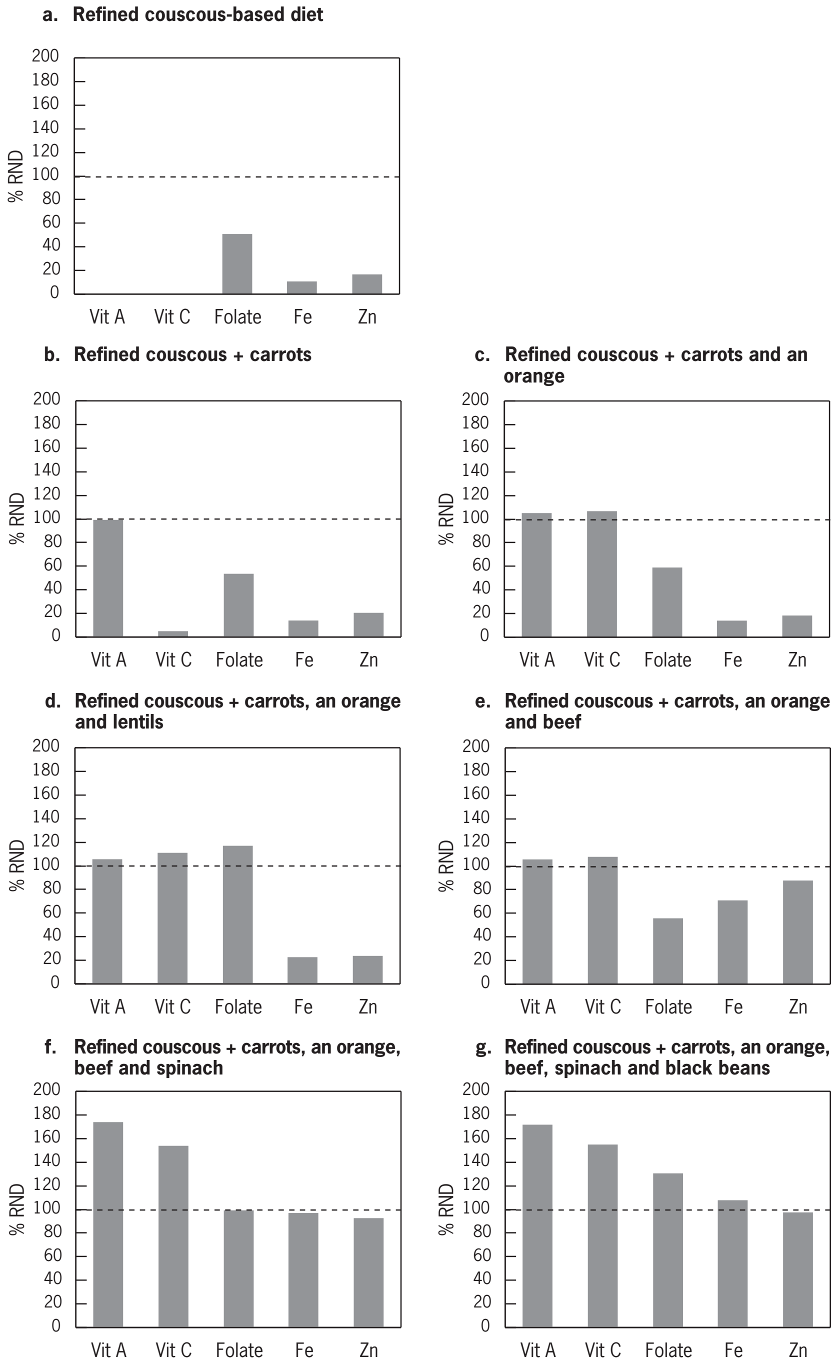
FIGURE 17.2
Impact of the addition of selected micronutrient-rich foods to a corn-tortilla-based diet on the recommended nutrient density (RND) of vitamin A, vitamin C, folate, iron (Fe) and zinc (Zn)



Source: adapted from reference (*2*).

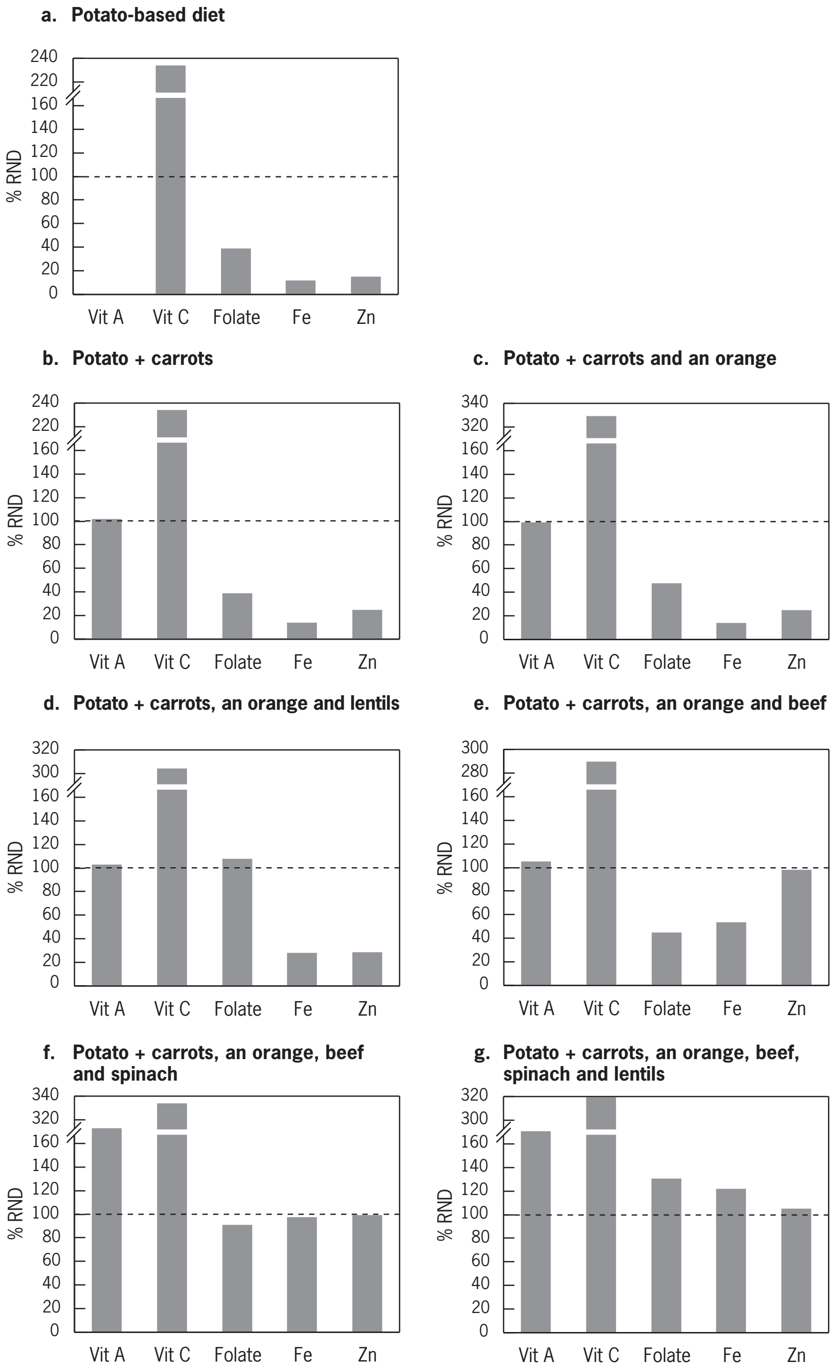
FIGURE 17.3

Impact of the addition of selected micronutrient-rich foods to a refined couscous-based diet on the recommended nutrient density (RND) of vitamin A, vitamin C, folate, iron (Fe) and zinc (Zn)



Source: adapted from reference (*2*).

FIGURE 17.4
Impact of the addition of selected micronutrient-rich foods to a potato-based diet on the recommended nutrient density (RND) of vitamin A, vitamin C, folate, iron (Fe) and zinc (Zn)



Source: adapted from reference (*2*).

17.2 Dietary diversification when consuming cereal- and tuber-based diets

Dietary diversification is important to improve the intake of critical nutrients. How this can be achieved is illustrated below with reference to five micronutrients, which are considered to be of public health relevance or serve as markers for overall micronutrient intake. The nutrients selected for discussion include those that are among the most difficult to obtain in cereal- and tuber-based diets (i.e. diets based on rice, corn, wheat, potato or cassava). Moreover, nutrient deficiencies of vitamin A, iron, and zinc are widespread.

17.2.1 Vitamin A

The vitamin A content of most staple diets can be significantly improved with the addition of a relatively small portion of plant foods rich in carotenoids, the precursors of vitamin A. For example, a typical portion of cooked carrots (50 g) added to a daily diet, or 21 g of carrots per 4.184 MJ, provides 500 µg retinol equivalents, which is the recommended nutrient density for this vitamin. The biological activity of provitamin A varies among different plant sources; fruits and vegetables such as carrots, mango, papaya, and melon contain large amounts of nutritionally active carotenoids (*3*, *4*). Green leafy vegetables such as ivy gourd have been successfully used in Thailand as a source of vitamin A, and carotenoid-rich red palm oil serves as an easily available and excellent source of vitamin A in other countries. Consequently, a regular portion of these foods included in an individual's diet may provide 100% or more of the daily requirement for retinol equivalents (Figures 17.1–17.4b). Vitamin A is also present in animal food sources in a highly bioavailable form. Therefore, it is important to consider the possibility of meeting vitamin A needs by including animal foods in the diet. For example, providing minor amounts of fish or chicken liver (20–25 g) in the diet provides more than the recommended vitamin A nutrient density for virtually all population groups.

17.2.2 Vitamin C

An increased vitamin C intake can be achieved by including citrus fruit or other foods rich in ascorbic acid in the diet. For example, an orange or a small amount of other vitamin C-rich fruit (60 g of edible portion) provides the recommended ascorbic acid density (Figures 17.1–17.3c). Adding an orange per day to a potato-based diet increases the level of vitamin C threefold (Figure 17.4c). Other good vitamin C food sources are guava, amla, kiwi, cranberries, strawberries, papaya, mango, melon, cantaloupe, spinach, Swiss chard, tomato, asparagus, and Brussels sprouts. All these foods, when added to a diet or meal in regular portion sizes, will significantly improve the vitamin C density. Because ascorbic acid is heat labile, minimal cooking (steaming or stir-frying) is recommended to maximize the bioavailable nutrient. The significance of consuming vitamin C with meals is discussed relative to iron absorption below (see also Chapter 13).

17.2.3 Folate

Folate is now considered significant not only for the prevention of macrocytic anaemia, but also for normal fetal development. Recently, this vitamin was implicated in the maintenance of cardiovascular health and cognitive function in the elderly. Staple diets consisting largely of cereal grains and tubers are very low in folate but can be improved by the addition of legumes or green leafy vegetables. For example, a regular portion of cooked lentils (95 g) added to a rice-based diet can provide an amount of folate sufficient to meet the desirable nutrient density for this vitamin (Figure 17.1d). Other legumes such as beans and peas are also good sources of this vitamin, but larger portions are needed for folate sufficiency (100 g beans and 170 g peas). Cluster bean and colacasia leaves are excellent folate sources used in the Indian diet. Another good source of folate is chicken liver; only one portion (20–25 g) is sufficient to meet the desirable nutrient density for folate and vitamin A simultaneously. The best sources of folate are organ meats, green leafy vegetables, and Brussels sprouts. However, 50% or more of food folate is destroyed during cooking. Prolonged heating in large volumes of water should be avoided, and it is advisable to consume the water used in the cooking of vegetables.

17.2.4 Iron and zinc

Minerals such as iron and zinc are found in low amounts in cereal- and tuber-based diets. The addition of legumes slightly improves the iron content of such diets. However, the bioavailability of this non-haem iron source is low. Therefore, it is not possible to meet the recommended levels of iron in the staple-based diets through a food-based approach unless some meat or fish is included. For example, adding a small portion (50 g) of flesh food will increase the total iron content of the diet as well as the amount of bioavailable iron. For zinc, the presence of a small portion (50 g) of flesh food will secure dietary sufficiency of most staple diets (Figures 17.1–17.4e).

The consumption of ascorbic acid along with food rich in iron will enhance iron's absorption. There is a critical balance between enhancers and inhibitors of iron absorption. Nutritional status can be improved significantly by educating households about food preparation practices that minimize the consumption of inhibitors of iron absorption; for example, the fermentation of phytate-containing grains before the baking of breads to enhance iron absorption.

17.3 How to accomplish dietary diversity in practice

It is essential to create strategies which promote and facilitate dietary diversification in order to achieve complementarity of cereal- or tuber-based diets with foods rich in micronutrients in populations with limited financial resources or access to food. A recent FAO/International Life Sciences Institute publication (*5*) proposed strategies to promote dietary diversification as part of food-based approaches to preventing micronutrient malnutrition. These strategies, which are listed below, have been further adapted or modified by the present Expert Consultation:

- *Community or home vegetable and fruit gardens*. Support for small-scale vegetable and fruit growing should lead to increased production and consumption of micronutrient-rich foods (e.g. legumes, green leafy vegetables, and fruits) at the household level. The success of such projects depends on a good knowledge and understanding of local conditions as well as the involvement of women and the community in general. These are key elements for supporting, achieving, and sustaining beneficial nutritional change at the household level. Land availability and water supply are often constraints, and may require local government support before they are overcome. The educational effort should be directed towards securing appropriate within-family distribution, which considers the needs of the most vulnerable members of the family, especially infants and young children.
- *Raising of fish, poultry, and small animals (rabbits, goats, and guinea pigs).* Flesh foods are excellent sources of highly bioavailable essential micronutrients such as vitamin A, iron, and zinc. Raising animals at the local level may permit communities to access foods which otherwise would not be available because of their high costs. These types of projects also need some support from local governments or nongovernmental organizations to overcome cost constraints of programme implementation, including education and training on how to raise animals.
- *Implementation of large-scale commercial vegetable and fruit production.* The objective of such initiatives is to provide micronutrient-rich foods at

reasonable prices through effective and competitive markets which lower consumer prices without reducing producer prices. This will serve predominantly the urban and non-food-producing rural areas.

- *Reduction of post-harvest losses of the nutritional value of micronutrient-rich foods, such as fruits and vegetables*. Improvement of storage and food-preservation facilities significantly reduces post-harvest losses. At the household level, the promotion of effective cooking methods and practical ways of preserving foods (e.g. solar drying of seasonal micronutrient-rich foods such as papaya, grapes, mangoes, peaches, tomatoes, and apricots) may preserve significant amounts of micronutrients in foods, which in turn will lead to an increase of these nutrients in the diet. At the commercial level, appropriate grading, packing, transport, and marketing practices can reduce losses, stimulate economic growth, and optimize income generation.
- *Improvement of micronutrient levels in soils and plants, which will improve the composition of plant foods and enhance yields*. Current agricultural practices can improve the micronutrient content of foods by correcting soil quality and pH and by increasing soil mineral content where it has been depleted by erosion and poor soil conservation practices. Long-term food-based solutions to micronutrient deficiencies will require improvement of agricultural practices, seed quality, and plant breeding (by means of a classical selection process or genetic modification).

The green revolution made important contributions to cereal supplies, and it is time to address the need for improvements in the production of legumes, vegetables, fruits, and other micronutrient-rich foods. FBDGs can serve to re-emphasize the need for these crops.

It is well recognized that the proposed strategies for promoting dietary diversity need a strong community-level commitment. For example, the increase in the price of legumes associated with decreased production and lower demand needs to be corrected. The support of local authorities and government may facilitate the implementation of such projects because these actions require economic resources, which are sometimes beyond the reach of those most in need of dietary diversity.

17.4 Practices which will enhance the success of food-based approaches

To achieve dietary adequacy of vitamin A, vitamin C, folate, iron, and zinc by using food-based approaches, food preparation and dietary practices must be considered. For example, it is important to recommend that vegetables rich in vitamin C, folate, and other water-soluble or heat-labile vitamins are minimally cooked in small amounts of water. In the case of iron, it is essential to reduce the intake of inhibitors of iron absorption and to increase the intake of enhancers of absorption in a given meal. Following this strategy, it is recommended to increase the intake of germinated seeds; fermented cereals; heat-processed cereals; meats; and fruits and vegetables rich in vitamin C. In addition, the consumption of tea, coffee, chocolate, or herbal infusions should be encouraged at times other than with meals (see Chapter 13). Consumption of flesh foods improves zinc absorption whereas it is inhibited by consumption of diets high in phytate, such as diets based on unrefined cereals. Zinc availability can be estimated according to the phytate–zinc molar ratio of the meal (*6*) (see Chapter 12).

This advice is particularly important for people who consume cereal-based and tuber-based diets. These foods constitute the main staples for most populations of the world, populations which are also most at risk for micronutrient deficiencies. Other alternatives—fortification and supplementation—have been proposed as stopgap measures when food-based approaches are not feasible or are still under development. There is a definite role for fortification in meeting iron, folate, iodine, and zinc needs. Fortification and supplementation should be seen as complementary to food-based strategies and not as a replacement. Combined implementation of these strategies can lead to substantial improvements in normalizing the micronutrient status of populations at risk. Food-based approaches usually take longer to implement than supplementation programmes, but once established they are truly sustainable.

17.5 Delineating the role of supplementation and food fortification for micronutrients which cannot be supplied by food

Under ideal conditions of food access and availability, food diversity should satisfy micronutrient and energy needs of the general population. Unfortunately, for many people in the world, the access to a variety of micronutrient-rich foods is not possible. As demonstrated in the analysis of cereal- and tuber-based diets (see Figures 17.1–17.4), micronutrient-rich foods, including small amounts of flesh foods and a variety of plant foods (vegetables and fruits), are needed daily. This may not be realistic at present for many communities living under conditions of poverty. Food fortification and food supplementation are important alternatives which complement food-based approaches to satisfy the nutritional needs of people in developing and developed countries.

17.5.1 Fortification

Fortification refers to the addition of nutrients to a commonly eaten food (the vehicle). It is possible for a single nutrient or group of micronutrients (the fortificant) to be added to the vehicle, which has been identified through a process in which all stakeholders have participated. This approach is accepted as sustainable under most conditions and is often cost effective on a large scale when successfully implemented. Both iron fortification of wheat flour and iodine fortification of salt are examples of fortification strategies that have produced excellent results (*7*).

There are at least three essential conditions which must be met in any fortification programme (*7*, *8*): the fortificant should be effective, bioavailable, acceptable, and affordable; the selected food vehicle should be easily accessible and a specified amount of it should be regularly consumed in the local diet; and detailed production instructions and monitoring procedures should be in place and enforced by law.

Iron fortification

Food fortification with iron is recommended when dietary iron is insufficient or the dietary iron is of poor bioavailability, which is the reality for most people in the developing world and for vulnerable population groups in the developed world. Moreover, the prevalence of iron deficiency and anaemia in vegetarians and in populations of the developing world which rely on cereal or tuber foods is significantly higher than in omnivorous populations.

Iron is present in foods in two forms, as haem iron, which is derived from flesh foods (meats and fish), and as non-haem iron, which is the inorganic form present in plant foods such as legumes, grains, nuts, and vegetables (*9*, *10*). Haem iron is the more readily absorbed (20–30%) and its bioavailability is relatively unaffected by dietary factors. Non-haem iron has a lower rate of absorption (2–10%), depending on the balance between iron absorption inhibitors (e.g. phytates, polyphenols, calcium, and phosphate) and iron absorption enhancers (e.g. ascorbic and citric acids, cysteine-containing peptides, ethanol, and fermentation products) present in the diet (*9*, *10*). Because staple foods around the world provide predominantly non-haem iron sources of low bioavailability, the traditionally eaten staple foods represent an excellent vehicle for iron fortification. Examples of foods that have been fortified are wheat flour, corn (maize) flour, rice, salt, sugar, cookies, curry powder, fish sauce, and soy sauce (*9*). Nevertheless, the beneficial effects of consumption of iron absorption enhancers have been extensively proven and should always be promoted (i.e. consumption of a vitamin C-rich food together with the non-haem iron source).

Iodine fortification

Iodine is sparsely distributed in the Earth's surface and foods grown in soils with little or no iodine lack an adequate amount of this micronutrient. This situation had made iodine deficiency disorders exceedingly common in most of the world and highly prevalent in many countries before the introduction of salt iodination (*11*). Only foods of marine origin are naturally rich sources of iodine. Salt is a common food used by most people worldwide, and the establishment of a well-implemented permanent salt-iodination programme has been proven to eradicate iodine deficiency disorders. Universal salt iodination is the best way to virtually eliminate iodine deficiency disorders (*5*).

However, salt iodination is not simply a matter of legislating the mandatory iodination of salt. It is important to determine the best fortification technique, coordinate the implementation at all salt production sites, establish effective monitoring and quality control programmes, and measure the iodine fortification level periodically. The difficulties in implementing salt iodination programmes arise primarily when the salt industry is widely dispersed among many small producers. The level of iodine fortification usually lies between 25 and 50 mg/kg salt. The actual amount should be specified according to the level of salt intake and the magnitude of the deficit at the country level, because iodine must be added within safe and effective ranges. Thus, it is very important to implement a monitoring plan to control the amount of iodine in the salt at the consumer's table (*11*, *12*). Additionally, United Nations agencies responsible for assisting governments in establishing iodination programmes should provide technical support for programme implementation, monitoring, and evaluation to ensure sustainability.

Zinc fortification

The body depends on a regular zinc supply provided by the daily diet because stores are quite limited. Food diversity analysis demonstrates that it is virtually impossible to achieve zinc adequacy in the absence of a flesh food source (see Figures 17.1–17.4). Among flesh foods, beef is the best source of zinc, followed by poultry and then fish. Zinc fortification programmes are being studied, especially for populations that consume predominately plant foods. Fortification of cereal staple foods is a potentially attractive intervention which could benefit the whole population as well as target the vulnerable population groups, namely children and pregnant women. Such addition of zinc to the diet would decrease the prevalence of stunting in many developing countries with low-zinc diets, because linear growth is affected by zinc supply in the body.

Folic acid fortification

The recommended nutrient density for folic acid is 200 μg/4.184 MJ (*1*). Although this value is higher than other standards of reference, the increase in folic acid consumption by women of childbearing age is very important: it may improve birth weight and reduce the prevalence of neural tube defects (see Chapter 15). Elevated plasma homocysteine levels are considered to be an independent risk factor for heart disease; a higher intake of folic acid may also benefit the rest of the population because it may lower homocysteine levels in adults (see Chapter 15). In addition, folate may improve the mental condition of the elderly population (*13*, *14*).

Although the desirable folic acid density may be achieved through dietary diversity, it requires the daily presence of organ meats, green leafy vegetables, pulses, legumes, or nuts in the diet (*15*). Most population groups may not easily reach the appropriate level of folic acid consumption; therefore, folic acid fortification has been recommended. The United States initiated mandatory folic acid fortification of cereal-grain products in January 1998. The fortification level approved in the United States is 140 μg/100 g of product, which will increase the average woman's intake by 100 μg/day. This amount is considered safe (a dose that will not mask pernicious anaemia, which results from vitamin B_{12} deficiency) and though not optimal in most settings, should contribute to the prevention of neural tube defects (*16*).

17.5.2 Supplementation

Supplementation refers to periodic administration of pharmacologic preparations of nutrients as capsules or tablets, or by injection when substantial or immediate benefits are necessary for the group at risk. As established at the International Conference on Nutrition (*17*), nutritional supplementation should be restricted to vulnerable groups which cannot meet their nutrient needs through food (e.g. women of childbearing age, infants and young children, elderly people, low socioeconomic groups, displaced people, refugees, and populations experiencing other emergency situations). For example, iron supplementation is recognized as the only effective option to control or prevent iron deficiency anaemia in pregnant women. Supplementation with folic acid must be considered for women of childbearing age who have had a child with a neural tube defect to prevent recurrence.

17.6 Food-based dietary guidelines

FBDGs are an instrument and an expression of food and nutrition policy and should be based directly on diet and disease relationships of particular relevance to an individual country and/or group, such as pregnant and lactating women, children, and the elderly. Their primary purpose is to educate healthcare professionals and consumers about health promotion and disease prevention. In this way, priorities in establishing dietary guidelines can address the relevant public health concerns whether they are related to dietary insufficiency or excess. In this context, meeting the nutritional needs of populations takes its place as one of the components of food and nutrition policy goals along with the priorities included in the FBDGs for improved health and nutrition for a given population.

The world nutrition and health situation demonstrates that the major causes of death and disability have been traditionally related to malnutrition in developing countries and to the imbalance between energy intake and expenditure (which lead to obesity and other chronic diseases—diabetes, cardiovascular disease, hypertension, and stroke) in industrialized countries. The tragedy is that many suffer from too little food while others have diseases resulting from too much food; both, however, would benefit from a more balanced distribution of food and other resources. Although the nature of the health and nutrition problems in these two contrasting groups is very different, the dietary guidelines required to improve both situations are not. Most countries presently have the combined burden of malnutrition from deficit and increasing prevalence of obesity and other chronic diseases from overconsumption. The approaches to address the problems, however, should be country and population specific.

Although two thirds of the world's population depends on cereal-based or tuber-based diets, the other one third consumes significant amounts of animal food products. The latter group places an undue demand on land, water, and other resources required for intensive food production, which makes the typical Western diet not only undesirable from the standpoint of health but also environmentally unsustainable. If energy intake is balanced with the expenditure required for basal metabolism, physical activity, growth, and cellular repair, the dietary quality required for health is essentially the same across population groups.

Efforts in nutrition education and health promotion should include a strong encouragement for active lifestyles. Improving energy balance for rural populations in developing countries may mean increasing energy intake to normalize low body mass index (BMI, weight/height^2, calculated as kg/m^2), ensuring adequate energy stores for daily living. In sedentary urban populations, improving energy balance will mean increasing physical activity to decrease energy stores (body fat mass) and thus normalize BMI. Thus, the apparent conflicting goals—eradicating malnutrition while preventing overnutrition—are resolved by promoting an appropriate energy balance, which will lead to a normal BMI. Moreover, given that FBDGs should be ecologically sustainable, the types and amounts of foods included in a balanced diet are not very different for promoting adequate nutrition in the impoverished and preventing overnutrition in the affluent.

This is well exemplified by the similarities in the FBDGs across countries, whether represented by pyramids, rainbows, dishes or pots. It is obvious that consumption of excess energy will induce an increase in energy stores, which may lead to obesity and related health complications. Populations should consume nutritionally adequate and varied diets, based primarily on foods of plant origin with small amounts of added flesh foods. Households across all regions should select predominantly plant-based diets rich in a variety of vegetables and fruits, pulses or legumes, and minimally processed starchy staple foods. The evidence that such diets will prevent or delay a significant proportion of noncommunicable chronic diseases is consistent. A predominantly plant-based diet has a low energy density, which may protect against obesity. This should not exclude small amounts of animal foods, which make an important nutritional contribution to plant-food-based diets, as illustrated in the examples presented earlier (Figures 17.1–17.4). Inadequate diets occur when food is scarce or when food traditions change rapidly, as is seen in societies undergoing demographic transitions or rapid urbanization. Traditional diets, when adequate and varied, are likely to be generally healthful and more protective against chronic noncommunicable diseases than the typical Western diet, consumed predominantly in industrialized societies (*18*).

Reorienting food production, agricultural research, and commercialization policies needs to take into consideration FBDGs, which increase the demand for a variety of micronutrient-rich foods and thus stimulate production to meet consumption needs. Prevailing agricultural policies encourage research on production and importation of foods, which do not necessarily meet the requirements of FBDG implementation. For example, great emphasis is placed on cereals, horticultural crops for export, legumes for export, non-food cash crops, and large livestock. Necessary policy reorientation is required to ensure increased availability of micronutrient-rich foods within the local food system. Norway has successfully implemented agricultural and food production policies based on a national nutrition plan of action, providing economic incentives for the producer and consumer in support of healthful diets. The results speak for themselves, as Norway has experienced a sustained improvement in life expectancy and a reduction in deaths from cardiovascular disease and other chronic noncommunicable conditions.

17.7 Recommendations for the future

The Consultation acknowledged the limitations in its knowledge of the important factors which affect nutrient utilization, and recommended that the International Food Data System (INFoods) effort, led by FAO and the United Nations University (UNU), be strengthened. Special emphasis should be placed on the micronutrient composition of local diets as affected by the ecological setting by including an analysis of food components (nutrients or bioactive components), which may affect the bioavailability and utilization of critical micronutrients, and an analysis of cooked foods and typical food combinations as actually consumed by population groups. In addition, the development of FBDGs at the country level should be supported by United Nations agencies.

17.8 Future research needs

To facilitate the implementation of a food-based approach in the prevention of micronutrient deficiencies the following research needs were identified:

- food data system development, which includes development of a methodology for micronutrient composition of foods, organizing data retrieval, and reporting and dissemination through electronic means; this effort should include phytochemicals, antioxidants, and other components which may affect health and nutrition, with special emphasis on local foods which may be important for given cultures;
- identification and evaluation of optimal methods for cooking foods to preserve the nutrient value and enhance the bioavailability of micronutrients;
- development of better methods to preserve foods, especially micronutrient-rich foods, at the household and community levels;
- identification and propagation of agricultural methods which will enhance the yield, content, and biological value of micronutrient-rich foods;
- identification of optimal food combinations and serving size which will be most effective in preventing micronutrient deficits and methods of promotion for these food combinations at the community level;
- development of agricultural research to support the implementation of FBDGs;

- evaluation of the nutritional impact and cost–benefit of food-based approaches in combating micronutrient deficiencies.

References

1. *Preparation and use of food-based dietary guidelines. Report of a Joint FAO/WHO Consultation.* Geneva, World Health Organization, 1996 (WHO Technical Report Series, No. 880).
2. Oyarzun MT, Uauy R, Olivares S. Food-based approaches to improve vitamin and mineral nutrition adequacy. *Archivos Latinoamericanos de Nutricion* (Guatemala), 2001, 51:7–18.
3. *Requirements of vitamin A, iron, folate and vitamin B_{12}. Report of a Joint FAO/WHO Expert Consultation.* Rome, Food and Agriculture Organization of the United Nations, 1988 (FAO Food and Nutrition Series, No. 23).
4. Olson JA. Needs and sources of carotenoids and vitamin A. *Nutrition Reviews*, 1994, 52(Suppl. 2):S67–S73.
5. *Preventing micronutrient malnutrition: a guide to food-based approaches*. Washington, DC, International Life Sciences Institute Press, 1997.
6. *Trace elements in human nutrition*. Geneva, World Health Organization, 1996.
7. Lotfi M et al. *Micronutrient fortification of foods. Current practices, research, and opportunities*. Ottawa, The Micronutrient Initiative, and Wageningen, International Development Research Center/International Agricultural Center, 1996.
8. Viteri FE. Prevention of iron deficiency. In: Howson CP, Kennedy ET, Horwitz A, eds. *Prevention of micronutrient deficiencies. Tools for policy-makers and public health workers*. Washington, DC, National Academy Press, 1998, 3:45–102.
9. Hallberg L, Hulthén L, Gramatkovski E. Iron absorption from the whole diet in men: how effective is the regulation of iron absorption? *American Journal of Clinical Nutrition*, 1997, 66:347–356.
10. Allen LH, Ahluwalia N. *Improving iron status through diet. The application of knowledge concerning dietary iron bioavailability in human populations*. Arlington, VA, John Snow, and Opportunities for Micronutrient Interventions Project, 1997.
11. Stanbury JB. Prevention of iodine deficiency. In: Howson CP, Kennedy ET, Horwitz A, eds. *Prevention of micronutrient deficiencies. Tools for policy-makers and public health workers*. Washington, DC, National Academy Press, 1998, 5:167–201.
12. Sullivan KM et al., eds. *Monitoring universal salt iodization programs*. Ottawa, The Micronutrient Initiative, 1995.
13. Tucker KL et al. Folic acid fortification of the food supply. Potential benefits and risk for the elderly population. *Journal of the American Medical Association*, 1996, 2776:1879–1885.
14. Oakley GP, Adams MJ, Dickinson CM. More folic acid for everyone, now. *Journal of Nutrition*, 1996, 126(Suppl.):S751–S755.
15. Bower C. Folate and neural tube defects. *Nutrition Reviews*, 1995, 53(Suppl. 2):S33–S38.
16. Daly S et al. Minimum effective dose of folic acid for food fortification to prevent neural-tube defects. *Lancet*, 1997, 350:1666–1669.

17. *International Conference on Nutrition. World Declaration and Plan of Action for Nutrition, 1992*. Rome, Food and Agriculture Organization of the United Nations, 1992.
18. *Diet, nutrition, and the prevention of chronic diseases. Report of a WHO Study Group.* Geneva, World Health Organization, 1990 (WHO Technical Report Series, No. 797).