

## FOOD SOURCES

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### 1. Introduction

Food is an essential element for life. Historically, humans have depended on natural sources for food. Rapid population growth, particularly during the last few decades, has driven the need to increase food supply to meet with the fast growing demand. However, emphasis has been given to provision of staple foods, rather than a totality of diet, which is composed of several foods to provide the various constituents that the body needs for proper functioning.

Figure 1 presents the conceptual framework, relating various aspects to food sources with a sustainable life support perspective. Foods, whether from indigenous or non-indigenous sources, go through intermediate steps determined by culture, technology, and the economic system to be available for consumption. Some of these factors affect the sustainability of food sources. Progress in nutritional and food sciences reveals that nutrients and some non-nutrients present in foods are necessary for growth and physiological functions. To fulfill the body’s needs, *varieties* of foods must be eaten because some foods contain more (amount and types of) nutrients and non-nutrients than others. Due to the co-presence of these constituents in foods, their interaction must be understood and a balance of constituents is needed for full benefits to health. Further, to sustain healthy life, several food sources must be identified, made available, and consumed. Growth and well-being in health demands various functions of nutrient and non-nutrient constituents in foods. Thus, both the quantity and quality aspects of food sources must be considered and these will be discussed in the light of sustainable food sources.

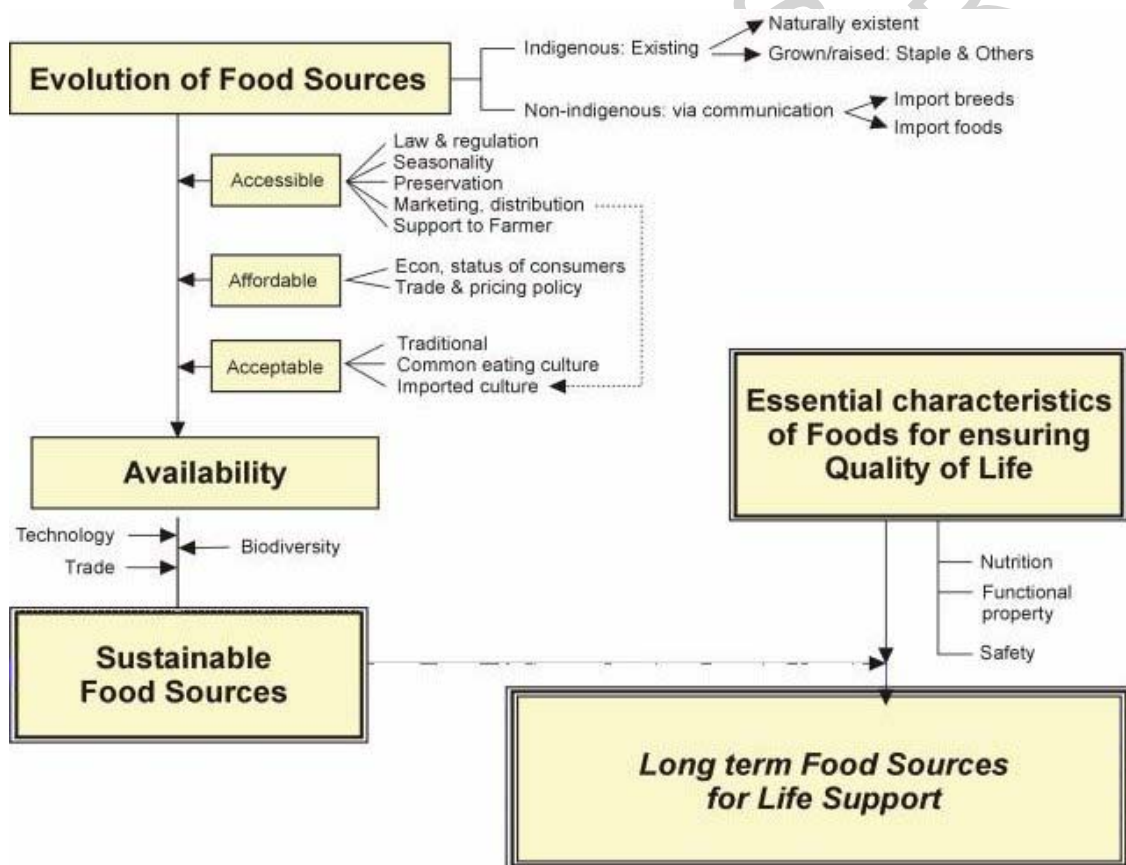


Figure 1. Conceptual framework.

## 2. Essential Characteristics of Foods: Ensuring Quality of Life

Adequacy of foods to sustain human survival and well-being includes not only adequate quantity, but also nutritive and functional quality and safety of foods. Foods consumed may contain nutrients, non-nutrients, anti-nutrients, and other functional constituents

such as phytochemicals.

The *nutritional adequacy* of each population is guided by the Dietary Reference Intakes, DRI (new concept introduced by the National Academy of Science, US, formerly known as Recommended Dietary Allowances, RDA), established for macro- and micronutrients. Requirements for nutrients have been identified, scientifically proven to have essential functions in the body, and reviewed periodically as new evidence emerges. The nutrient recommendations are made in terms of amounts of nutrients required daily by various age groups, sexes, and physiological groups (namely, pregnancy and lactation), to maintain proper growth, functions, and health.

Foods are sources of nutrients: carbohydrates, protein, fat, vitamins, and minerals. Energy is derived mainly from carbohydrates and fat, and also from protein when carbohydrate and fat intakes are inadequate. Major food sources for carbohydrates are cereal grains and starchy tubers and roots. Animals, fish, and dried seeds (pulses and legumes) provide both protein and fat. Vitamins and minerals are obtained from vegetables and fruits, though cereals, animal sources, and dried seeds also provide substantial amounts. Some tubers, such as sweet potatoes, and their leaves also contain carotenoids. Taro leaves (*Colocasia esculenta*), used in Asia and the Pacific, and cassava leaves (*Manihot esculenta*), used in humid tropical Africa, are good sources of pro-vitamin A. Eggs from a varieties of species, such as chicken, duck, quail (Asia) and guinea fowl (Africa), can provide complete essential amino acids. They are also good sources of vitamins and minerals. Fish, though apparently common, is still expensive for some populations, unless available by gathering from natural sources or aquaculture.

Nutrient and non-nutrient food constituents do not exist and function in isolation. They may synergistically interact to increase absorption, availability, and utilization, or antagonistically inhibit the each other's availability. These interactions are known as *nutrient bioavailability*. Therefore, to make nutritionally adequate meals, both the content and bioavailability of nutrients must be considered. Several nutrients and non-nutrients coexist in foods and foods are likely to be consumed in combination. Thus, interaction of nutrients and non-nutrients from the same dishes or among dishes eaten together can be expected. For example, high oxalate in foods exerts a negative effect on absorption of calcium and iron. Calcium in spinach which coexists with oxalate is not readily available when the oxalate to calcium ratio is larger than 2. Foods that contain no utilizable calcium, but have excessive oxalate, can interfere with calcium from other foods eaten at the same time (Noonan and Savage, 1999). Absorption of zinc can be interfered with by iron if the ratio of iron to zinc is larger than 4.

Another important function of food is to provide *physiologically functional ingredients*, which prevent certain diseases and promote good health. They are purported to be efficacious in the prevention and/or treatment of disease and the promotion of optimal health. Physiological functions usually include (i) biodefensiveness, (ii) rhythm of physical condition, (iii) prevention of degenerative conditions due to aging, and (iv) prevention of certain diet-related diseases. Physiologically active compounds or so-called functional ingredients are the substances that are naturally found or added into foods, and provide the physiological function to the body. The functional ingredients are usually of plant origin; however, they can be from animals and microorganisms.

Secondary metabolites in plants such as pigments, phenolic compounds (polyphenols), phytoestrogen, vitamins and their precursors are well-recognized functional ingredients. As antioxidants, many phytochemicals can have antimutagenic and anticarcinogenic effects. Polyunsaturated fatty acids found in flowers and seeds of certain plants also have physiological functions, especially prevention of cardiovascular disease and reduction of inflammation. Oils from tuna fish contain omega-3 fatty acids which have a preventive function for cardiovascular disease. Peptides derived from both plants and animal proteins are being studied for their effects on the brain, reduction of muscle fatigue, and promotion of the immune system. Certain strains of live lactic acid bacteria called “probiotics” are the most popular functional ingredients from microorganisms, which are known for their functions in preventing the growth of undesirable microorganisms in the gastrointestinal tract. Certain kinds of oligosaccharides called “prebiotics” are usually derived from plants and widely used to promote growth of lactic acid bacteria in human intestine.

Different parts of animals such as chitosan from the crustacean shell, shark cartilage, chicken essence, and bird nests, are claimed to have certain physiological functions. Indigenous knowledge and beliefs about the physiological functions of indigenous foods have been passed on for generations among local people in various parts of the world. Different parts of animals such as chitosan from the crustacean shell, shark cartilage, chicken essence, and bird nests, are claimed to have certain physiological functions. Some of the indigenous beliefs have only recently been scientifically proven, while many remain anecdotal and need more evidence from properly designed studies to verify their health benefits.

*Safety* is another essential characteristic of food. Consumption of unsafe food results in food-borne illnesses or other toxicity. Food-borne illness can occur from naturally occurring substances in food itself. It can be due to malpractices at any stage of the food chain, from farm to table. Contamination of food from microbial and chemical origins occurs during growing, harvesting, post-harvesting, processing, and preparation of food. Improper practices at any stage from food production to consumption can result in physical, chemical and/or microbial contamination and cause food-borne illness. Some foods contain natural toxins, which can cause illness or even death. However, some of these toxins when present in small amounts may have physiological functions in humans.

There are many challenges associated with the emerging food-borne problems (Van de Venter, 2000). Changes in the pathogens are associated with microbial adaptation through natural selection, therapeutic use of antimicrobial agents, and pollution. Economic and technological development introduces new foods and an increase in mass catering. Changes in dietary habit and food choice associated with urbanization have also been observed. Higher living standards and urban lifestyle lead to increased use of prepacked, convenient foods, and eating at food service establishments. New food vehicles and channels of transmission are increasingly used, such as street vended foods, which are very common in several countries in Asia. Travelers can spread disease rapidly to new and distant environments.

### **3. Food Sources: An Evolutionary Perspective**

Natural foods have provided the means to support life in human history. Indigenous people depend largely on *indigenous foods* available in their surroundings by hunting and gathering. On land, forest is the major food source, complemented by foods from waterways. Near shores, dwellers also gain from access to the sea or ocean, another large natural source of foods. Choice of food varieties and breeds depends on the survival of the plants or animals under the soil and climatic condition of the locality. Several plant foods began as weeds such as amaranths, beans (*Phaseolus* spp.), squashes (*Cucurbita* spp.) and corn (maize) found in fields planted to cassava and sweet potato (Saurer, 1969). Generally, crops that started as weeds have passed three main stages to become human food sources. At first, they might be pulled, cut or dug into soil but as weeds proliferated, some could tolerate and survive. Planting occurred when weeds had accompanied farmers long enough for them to see their uses. Obtaining food and collecting wood for fuel were dominant activities in traditional agricultural societies. Development of agriculture made it easier and less time-consuming to secure food supplies for both food producers and nonfood producers. Food/energy surplus could be planned for and used to support nonfarmers in the society (Spelman, 1994).

According to the US National Academy of Sciences, human beings have exploited about 3000 species out of 250 000 species of flowering plants, and 150 species are cultivated on a commercial scale (Tudge, 1988). Hunters and gatherers may make regular use of only 80 or more different plants and a wide variety of animal foods. However, the largest amount of food for human beings is supplied by only about 20 different kinds of crop. Only 15 plants accounted for three-quarters of all plant calories for human consumption (Wilkes, 1977). These included 5 grasses: rice, wheat, corn, barley, and sorghum; 3 legumes: soybeans, common beans, and peanuts; 2 sugar sources: sugar cane, sugar beet; 2 tropical trees: coconuts and bananas, and 3 starchy root crops: potatoes, yams, and cassava. This leaves humans very vulnerable because only a limited number of food varieties are relied on.

In animal husbandry, the first animals kept were probably chicken, duck, pigs, rabbits, sheep, goat, and cattle. They provided both food and a source of non-food materials. Poultry and small animals are used mainly for food, while draft animals provide both food and power. However, when they provide power, they consume about 20% of the total agricultural production from the farm. The use of animal power to draw a plow, and later the invention of the tractor, were breakthroughs in agricultural production. Maintaining herds of animals both for food and for other uses also gave security to the food supply.

Trading for food is also common in traditional society, mostly by bartering of food for food and food for nonfood items. In a cash economy system or less traditional societies, foods may be traded by monetary exchange. Facilitated by technological development and communication means, foods may be taken away from their original places and become *non-indigenous* to the new places. These food sources may be as important as indigenous foods. Immigrants introduce new foods and dietary habits or food culture from the previously familiar one to another culture, or mixed with the local culture. In addition, indigenous people may adopt the new culture brought in by foreigners so that it becomes their own culture. Trade in food, animal feed, and animals as a result of globalization and trade liberalization leads to rapid movement of food (plant and animal

origins) from place to place. In special conditions, for example insufficient production or where repeated natural calamity is the problem, the same food as the indigenous item may also be brought in from other places.

#### **4. Sources of Foods**

##### **4.1 Indigenous Foods**

Prior to formal crop production, wild plants and animals were the staple foods. Indigenous plants and animals were gathered locally or gathered and hunted in the nearby forests and waterways. Wild food plants are those grown naturally in the bush or near the homestead. These are indigenous sources that serve subsistent needs; for example, sorghum, finger millet, cassava, and several fruits and vegetables are indigenous food sources in Africa (FAO, 1988).

Traditional or indigenous food sources may be plants or animals that are consumed by indigenous people of the area (FAO, 1988; Hoe and Siong, 1999). In Africa, several plants traditionally consumed have good nutritive value. Edible parts may be young leaves or stems, flowers and fruits, and may be eaten fresh, cooked as side dishes or garnishment. They may be seasonally available, or different parts used in different seasons. These plants may be from the farm or home garden, and natural sources. An in-depth study in a rural community in northeastern Thailand reported that 126 food items were gathered from the forest and farms at different times of the year. These included both animals and plants and some foods from unconventional sources, such as insects, amphibians (frog, young toad), ground lizard, and freshwater algae (Kunarattanapruk et al., 1998).

Several indigenous foods and processing may improve micronutrients in diets (FAO, 1993). In humid tropical countries, green leafy plants, such as *Amaranthus* spp., *Corchorus* spp., *Bidens pilosa*, *Gynandropsis* spp., *Celosia* spp., *Basella* spp., *Solanum scabrum*, *Solanum americanum*, *Hibiscus sabdariffa*, and *Vigna unguiculata*, often grow wild. Traditionally, they are consumed as leafy vegetables. Since they are already consumed in typical diets, knowing that these leaves are good sources of protein, phosphorus, iron, vitamin A and C, and possibly B makes their use an attractive way to improve diets. In Mali, baobab leaves (*Adansonia digitata*) are locally gathered and are typically sun-dried and pounded into powder and cooked into the daily family sauce. Small leaves have higher content than large leaves. Shade-drying was found to double pro-vitamin A and carotenoids. Thus, the combination of small leaf and drying resulted in increased pro-vitamin A. In addition, baobab fruits are good sources of vitamin C but the contents varied as much as threefold from different trees (150–500 mg/100 g). Using simple technology in the village, complementary foods consisting of millet and cow pea could be formulated. Adding baobab leaves and fruits were developed to improve nutritive quality (Sidibe et al., 1998; Noreide et al., 1996). In addition to their use as foods, several of traditional plants have also been used for their medicinal properties. Efforts are being made worldwide to identify and quantify the content of active ingredients in indigenous foods that may have physiologically functional properties to health.

Simple processing may increase micronutrients (ACC/SCN, 1998). For example, in Mali, baobab leaves (*Adansonia digitata*) are locally gathered and are typically sun-dried and pounded into powder and cooked into the daily family sauce. Small leaves have higher content than large leaves. Shade-drying was found to double pro-vitamin A and carotenoids. Thus, the combination of small leaf and drying resulted in increased pro-vitamin A. In addition, baobab fruits are good sources of vitamin C but the contents varied as much as threefold from different trees (150–500 mg/100 g). Using simple technology in the village, complementary foods consisting of millet and cow pea could be formulated. Adding baobab leaves and fruits were developed to improve nutritive quality (Sidibe et al., 1998; Noreide et al., 1996). Foods, such as insects, that may seem unconventional to other populations may be consumed by indigenous people. Analysis of the nutritive values of several insects consumed by rural villagers in northeast Thailand revealed that insects contained significant amounts of protein and energy (Yhoung-aree et al., 1997).

In addition to plants, freshwater fish, shrimp, crab, and frog are important animal protein sources. The rainy season is the time when food is most abundant. Food preservation of some vegetables and animals can also be done. During the cool, dry season, which coincides with rice harvest time, plants are available from home gardening and a few from the forest. During the hot, dry season, plants are available mainly from home gardening. Other sources include the surrounding waterways or local markets (Seradi, 1993). In northwestern Benin, seasonality not only changes food items/groups, but also the means of food acquisition. Gifts and purchased foods formed a major part for the household when the stock of staple was low (Van Liere, 1995). Energy intake from farm produce also declined from 80% to 65%, with a corresponding increase in wild food consumption in rural communities in Ghana, during the lean season (Dei, 1989). In Kenya, purchased food and gifts replaced own production (Neuman et al., 1989).

Despite the current knowledge on nutritive values and quality of diets that can be composed to meet the nutritional needs of indigenous people, promotion of the uses of indigenous sources is clearly needed. Food production focusing on commodities that have commercial value should shift to promoting the consumption of indigenous food sources. This, in turn, will focus attention on identifying nutritious indigenous food sources and on further improvement of quality and production of indigenous food sources. Medicinal properties should also be studied so that their health benefits can be better appreciated.

#### **4.2 Foods from Natural Waters**

The World Resources Institute (WRI) reported in 1996 that half of the world's coastal resources are at moderate to high risk of degradation. Coastal fish habitats are being rapidly degraded by industrial, urban and agricultural pollution, landfill, damming and diversion of rivers, clearance of mangrove, sedimentation, mining and oil exploration and extraction. Increased marine fish production is only possible if fish stocks are rebuilt and the balance of the marine food chain is restored. Inland waters also encounter problems of environmental degradation, resulting in fewer catches and smaller fish. The natural fish stock has been overexploited by aggressive fishing

techniques and severe degradation of marine and coastal environments. Fishery practices that have adverse effects on aquatic habitats include use of bottom trawls, dredges and explosives, and anchoring of crafts (FAO, 1998). Important damage can happen if there are large numbers of by-catch (unintended catch or nontargeted fish or undersized fish) of juveniles of commercial species because this reduces the future number of mature fish. It is important to find a strategy to reduce losses due to by-catches and discards. Overfishing is particularly severe in densely populated coastal and productive offshore areas (FAO, 1996).

The success of control measures depends very much on the level of international cooperation and willingness of states to control their fishing vessels. Since the early 1970s, the UN has set out to obtain a consensus on fair sharing of ocean resources by member states. Though the effort was not successful, several countries having large coastal interests declared unilateral 200 mile economic zones (King, 1977). Better management should result in increased income and greater catch volumes. However, even with effective management, these measures will only prevent long-term decline in production, rather than producing a noticeable increase in capture fishery production. Fish are major protein and important micronutrient foods in developing countries, but consumption levels are much lower than in developed countries. Maintaining these resources and making them accessible will be particularly important for developing countries.

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### Biographical Sketches

**Professor Aree Valyasevi** received his medical degree from Siriraj Medical College in Bangkok, Thailand in 1951. He pursued graduate studies at the University of Pennsylvania and received D.Sc. in 1959 (and American Board of Paediatrics in 1957). He is the Founding Dean of two medical schools, Ramathibodi Medical School, Mahidol University (1967-1977), and Thammasat University Medical School (1990-1996). He is the Founding Director of the Institute of Nutrition, Mahidol University (1978-1988). He served as the President of Asian Nutrition Societies, Vice-President (1988-1992) and President of the International Union of Nutritional Sciences (1993-1997), and President of Federation of Paediatric Nutrition Organization in Asia (2000). Professor Valyasevi has been known of his leadership and outstanding scientific contribution in nutrition, specifically, the urinary bladder stone diseases in young children, nutritional problem and intervention for its alleviation in rural community. He authored over 80 publications. He is the recipient of several Thai and world renowned awards for his contribution as a scientist and in public service. In Thailand, he received Dusadi-mala, the Medal of Appreciation for public service, Distinguished Research Award and outstanding scientist from Thailand National Research Council. He received international recognition, namely, the Ramon Magsaysay Award (1987), the E. V. McCollum International Lectureship in Nutrition (1989), Foreign Associate of the National Academy of Sciences, USA (1993).

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