# Fortification Basics

## Choosing a Vehicle

### Rationale

Fortification of foods with vitamins and minerals can be an effective way to combat micronutrient deficiencies in developing countries. One of the key processes in developing a fortification program (Table 1) is choosing a suitable food vehicle. This can be a challenge, especially in countries with large rural populations, a small food industry with limited technology, and limited access and low consumption of processed foods. Some foods that are suitable for fortification, such as commercial infant foods (many of which are fortified), processed fruit juices, and processed milks are generally consumed by middle or high income groups who are not always at greatest risk of micronutrient deficiencies. Some staple foods, such as rice, are generally processed in many plants, making it difficult to transfer appropriate technology and to implement quality control. Examples of foods used in fortification programs in developing countries are listed in Table 2.

Selecting an appropriate vehicle and having an effective fortification program that provides a significant amount (programs have used 33% to 50%) of the recommended daily intake of micronutrient(s) for those at greatest risk of deficiency, reduces the need to provide supplements in pharmaceutical forms on a widespread basis.

### Criteria for vehicle selection

The success of a fortification program depends, in part, on the selection of the right food vehicle. This requires knowledge of food intake patterns that show who is eating what foods among the groups at greatest risk of deficiency. The selection of a vehicle should be based on several key factors:

- it must be centrally processed so that quality control can be effectively implemented.
- it must be consumed regularly and in predictable amounts, and be affordable by the target population.
- the stability and bioavailability of the micronutrients added to the food must remain high under standard local conditions of storage and use.
- the fortified food should not undergo changes in color, taste, or appearance as a result of adding the micronutrients.
- the addition of micronutrients should be economically feasible through an industrial process.
- the added nutrient should supply optimal amounts without

Table 1
**Development of a Fortification Program**

| |
|---|
| Determining the prevalence of micronutrient deficiency |
| Choosing a suitable food vehicle:<br>• Food production and consumption data for potential food vehicles segregated by socio-economic and age groups and geographic area.<br>• Marketing and distribution patterns for food vehicle. |
| Determining the level of fortificant to be added |
| Developing a quality assurance system |
| Monitoring and evaluating the fortification program |
| Legislating and enforcing laws to ensure fortification of foods |

Table 2
**Some Foods Considered in Food Fortification Programs in Developing Countries**

| Food | Intervention | Countries | Fortificant |
|---|---|---|---|
| **Sugar** | Program (Mandatory) | Guatemala<br>El Salvador<br>Honduras | Vitamin A |
| **MSG** | Experimental | Philippines<br>Indonesia | Vitamin A |
| **Salt** | Program (Mandatory) | Numerous | Iodine |
| **Corn flour** | Program (Mandatory) | Venezuela | Vitamin A, Iron<br>Thiamin, Niacin<br>Riboflavin |
| **Wheat flour** | Program (Mandatory) | Chile, Peru<br>Honduras<br>El Salvador<br>Guatemala<br>Venezuela<br>Panama<br>Costa Rica<br>Nigeria | Thiamin,Niacin, Riboflavin, Iron, and in some countries Folic Acid |
| | Experimental | Philippines | Vitamin A, Iron |

*Table 2 (continued)*

| | | | |
|---|---|---|---|
| **Margarine** | Program (Mandatory) | Brazil, Chile, Colombia, Mexico, Peru, Honduras, Ecuador, Panama | Vitamins A&D |
| **Oil** | Experimental Voluntary | Brazil Chile | Vitamin A Vitamins A&E |
| **Ghee** | Program (Voluntary) | Pakistan | Vitamin A |
| **Noodles** | Program (Voluntary) | Thailand | Vitamin A Iron B Complex |
| **Milk** | Program (Mandatory) | Argentina, Brazil, Mexico, Honduras, Guatemala, Malaysia | Vitamins A&D |

Table 3
**Per Capita Wheat Consumption, and Percent of Daily Energy Intake from Wheat in Selected Countries**

| Country | Consumption (g/person/day) | % of daily energy intake |
|---|---|---|
| Pakistan | 318 | 45 |
| Turkey | 484 | 44 |
| Syria | 490 | 44 |
| Chile | 372 | 42 |
| Egypt | 397 | 35 |
| Greece | 371 | 28 |
| Argentina | 344 | 28 |
| Uruguay | 269 | 26 |
| Bolivia | 159 | 20 |
| South Africa | 191 | 18 |
| Peru | 136 | 17 |

FAO, 1991. Food Balance Sheets 1984-1986, Rome.

Table 4
**Per Capita Corn Consumption, and Percent of Daily Energy Intake from Corn in Selected Countries**

| Country | Consumption (g/person/day) | % of daily energy intake |
|---|---|---|
| Bolivia | 97 | 16 |
| Brazil | 90 | 10 |
| Egypt | 151 | 16 |
| Guatemala | 319 | 48 |
| Honduras | 258 | 41 |
| India | 21 | 3 |
| Indonesia | 74 | 8 |
| Nepal | 116 | 18 |
| Philippines | 132 | 15 |
| South Africa | 308 | 30 |
| Venezuela | 122 | 14 |
| Zambia | 477 | 68 |

FAO, 1991. Food Balance Sheets 1984-1986, Rome.

a risk of excessive intake or toxic effects.

### Food vehicles

Foods that have been successfully fortified in developing countries include:

- **Sugar.** Vitamin A fortification of sugar has been implemented in Guatemala, Honduras, and El Salvador and is being considered in Ecuador, Nicaragua, Philippines, Uganda, and Zambia.
- **Wheat flour.** Fortification of wheat flour with thiamin, riboflavin, niacin, and iron has been successfully used for a long time. Studies conducted in the U.S. showed good stability of vitamin A added to wheat flour. Efficacy trials on wheat flour fortification with vitamin A, and wheat flour with iron are currently underway in the Philippines and Sri Lanka, respectively.
- **Corn flour.** In Venezuela, precooked corn flour is fortified with vitamin A, thiamin, riboflavin, niacin, and iron.
- **Salt.** Salt is fortified with iodine in many countries throughout the world. Work is currently underway to test the efficacy of salt that is fortified with both iodine and iron.
- **Fats and oils.** Fats and oils may serve as good vehicles for vitamin A because vitamin A is fat soluble. Vegetable ghee (hydrogenated vegetable oil) is fortified in India and Pakistan.

  Margarine is fortified with vitamin A in about 24 countries, including Brazil, Chile, Colombia, Mexico, Indonesia, and many others.Trials on vitamin A fortified soybean oil are underway in Brazil.
- **Milk.** Milk has been successfully fortified with vitamins A and D for many years. One of the latest successful experiences in fluid milk fortification with iron occurred in Argentina.

To identify a good food vehicle, data are needed on food production, imports, and exports. Foods that are locally produced or home grown, and not centrally processed, such as rice in Asia, are not effective vehicles for delivering micronutrients because it is difficult to make the fortificant available to the many thousands of small producers/processors.

Similarly, non-staple foods may not be effective in reducing the prevalence of micronutrient deficiencies because they are generally not consumed by the target populations.

Finally, the role of imported foods should be considered. Leakage of non-fortified foods across international borders may dilute the effect of a fortification program. Where food regulations exist, imported foods must comply with the local food regulations.

### Consumption patterns

Information on consumption patterns is necessary to identify

an appropriate vehicle for fortification. For example, worldwide consumption patterns of wheat, corn, oil, and sugar, presented in tables 3, 4, 5, and 6, respectively, show that these foods are potentially good vehicles for fortification. Unless the food is eaten in predictable amounts on a regular basis by the target population, the program will not be effective. Knowledge of consumption levels are also needed to determine how much micronutrient(s) can be safely added to the food vehicle.

Differences in foods consumed by urban versus rural populations exist and must be considered before choosing a fortification vehicle. For example, urban populations in Brazil consume a wide variety of foods (Figure 1) that are not typically consumed by the rural populations (Figure 2).

The choice of a vehicle should ideally be based on consumption data for children under 5 years of age and pregnant women, who are most vulnerable to micronutrient deficiencies because of their increased requirements for growth and development. Where possible, consumption data should be segregated by different social and economic groups and also by different geographic/ecological regions.

## Marketing and distribution

The marketing and distribution plans for the food vehicle need to be known to ensure that the fortified foods reach the most isolated populations, who are the most vulnerable to micronutrient deficiencies.

Marketing patterns may vary from country to country. Fortified products such as sugar, salt, and cereal flours generally pass through a series of distribution points between wholesalers and retailers before being sold to consumers. Involving both the private and public sector in the marketing and monitoring of fortified foods will increase the likelihood of the program being effective.

Food producers and processors should be encouraged to make appropriate nutritional claims, in accordance with local regulations, for a properly fortified product to provide adequate information to the consumer. This should be done through product labeling and appropriate advertising and promotion of the fortified food.

## Stability of micronutrients in fortified food

Micronutrient losses can occur at each point in the distribution chain, if storage conditions are not optimal. Exposing fortified food to light, air, heat, and humidity may result in losses of some micronutrients and their potency.

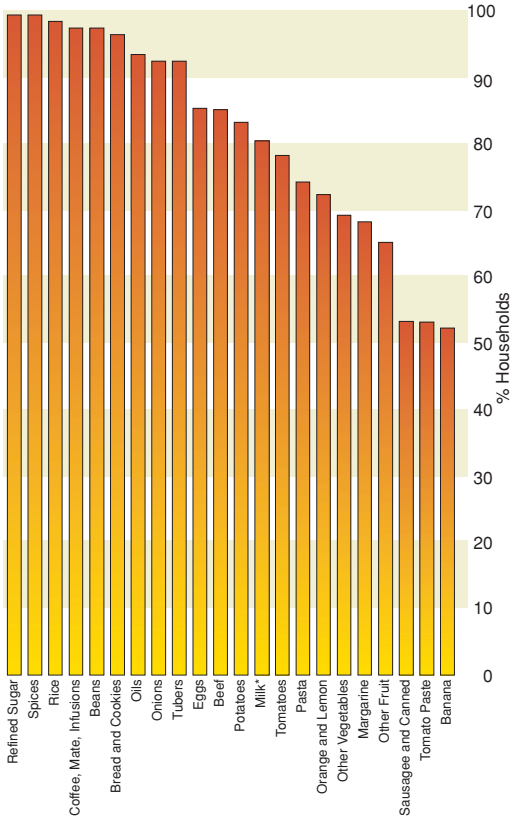
Micronutrient losses can also occur at the household level during storage and food preparation. Thus, data are needed on ambient storage conditions at different points in the distribution chain and at the household level before deciding on the type and form of fortificants that can be added to improve micronutrient status.

Table 5
**Per Capita Vegetable Oil Consumption, and Percent of Daily Energy Intake from Vegetable Oils in Selected Countries**

| Country | Consumption (g/person/day) | % daily energy intake |
|---|---|---|
| Brazil | 33 | 9 |
| Mexico | 27 | 9 |
| Costa Rica | 30 | 9 |
| Central Africa | 35 | 11 |
| Congo | 12 | 5 |
| Gambia | 34 | 12 |
| India | 31 | 11 |
| Indonesia | 16 | 7 |
| Nepal | 17 | 6 |
| Philippines | 12 | 4 |

FAO, 1991. Food Balance Sheets 1984-1986, Rome.

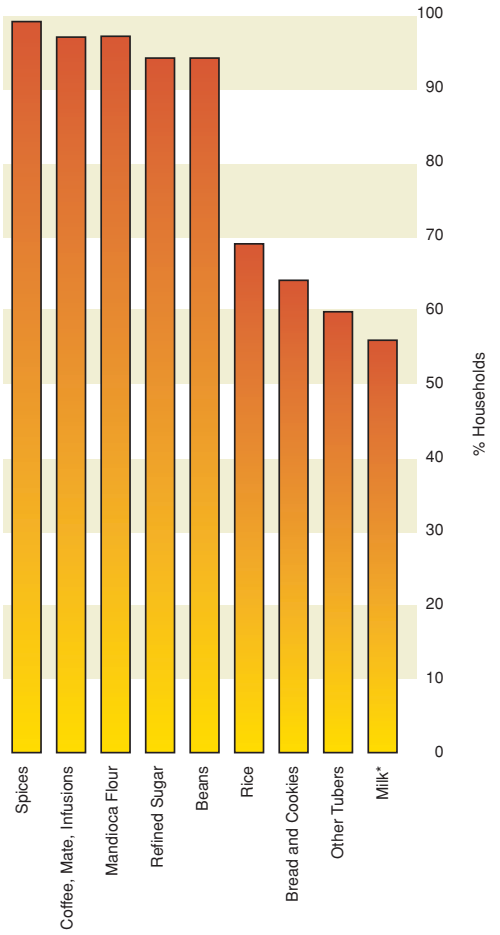
Figure 1
**Typical Foods Consumed by Households with Children Under 5 Years of Age in Urban Sao Paulo, Brazil**




Batista Filho, M., N.P. Barbosa. Alimentaçao e Nutriçao no Brasil: 1974-1984. Instituto Nacional de Alimentaçao e Nutriçao. Brasil, 1989.
* Fresh and Pasteurized

Figure 2

**Typical Foods Consumed by Households with Children Under 5 Years of Age in Rural Northeast Brazil**




Batista Filho, M., N.P. Barbosa. Alimentaçao e Nutriçao no Brasil: 1974-1984. Instituto Nacional de Alimentaçao e Nutriçao. Brasil, 1989.

* Fresh and Pasteurized

Table 6

**Per Capita Sugar Consumption, and Percent of Daily Energy Intake from Sugar in Selected Countries**

| Country | Consumption (g/person/day)[1] | % of daily energy intake[2] |
|---|---|---|
| Brazil | 127 | 17 |
| Peru | 88 | 14 |
| Guatemala | 110 | 15 |
| Honduras | 85 | 12 |
| India | 42 | 5 |
| Indonesia | 42 | 5 |
| Morocco | 88 | 11 |
| Mali | 22 | 2 |
| Egypt | 80 | 10 |
| Zambia | 31 | 8 |
| Cameroon | 17 | 3 |
| South Africa | 100 | 15 |

[1] International Sugar Association, 1995.
[2] FAO, 1991. Food Balance Sheets 1984-1986, Rome.

## Sensory characteristics

One of the advantages of fortification is that it can be achieved without changing the sensory properties of the food. If consumers, however, notice that there is a difference in the taste, smell, or texture of the food as a result of fortification, they may not buy the fortified food. Sensory characteristics can play an important role in determining the amount of micronutrient added to the food. For example, the amount of riboflavin (vitamin $B_2$) added to corn flour can be limited by the extent to which the change in color, caused by the addition of riboflavin, is acceptable to consumers.

## Data sources

Data on the production and availability of potential food vehicles can be obtained from government offices, trade associations, banks, and other agencies.

Data on food consumption and distribution are generally not easy to obtain from official sources. However, some food companies, and marketing and advertising firms conduct research to obtain these data. Many trade associations also gather and publish food consumption and distribution statistics, which are normally available to the public. Even though these data may be quite specific and specialized, they can be used as a reference, or indirectly to assess more general consumption patterns. It is important to note that data may only be available at a per capita consumption level, and not segregated by age groups.

In some countries, such as Bangladesh and the Philippines, national dietary surveys are carried out regularly, while in other countries, dietary surveys are carried out on a limited basis. Where consumption data do not exist, crude intake levels can be calculated from the FAO Food Balance Sheets that are based on production, export, and import data. These data, however, provide information at the per capita level only.

Food consumption by different socioeconomic groups may also be derived from household budget surveys that most countries undertake when constructing their cost of living indices. Again, these data may be available on a per capita basis only.

In conclusion, a food fortification vehicle should be chosen based on key factors, including consumption patterns, marketing and distribution data, and economic and technical feasibility.