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GUIDELINES FOR THE DEVELOPMENT OF PROCESSED AND PACKAGED WEANING FOODS

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INTRODUCTION

In order to develop and use foods of high nutritional quality, including weaning foods, for home preparation or industrial production, it is necessary to obtain background information on the food systems prevailing in the country, locality, and/or area where the food is to be developed. The food system includes three sectors: food production, storage, and marketing; food availability and food consumption patterns; and the national capacity for food processing.

The information should include different aspects on production, storage, availability, marketing and processing of foods, with emphasis on the basic staples, but not excluding other food items such as oilseeds, animal food products, fruits, vegetables, and other agricultural products likely to be produced. Likewise, information of significant value would be that obtained from food consumption practices, habits and taboos, weaning practices, frequency of intake of particular foods, food preparation, function and forms, and factors that modify the above as a whole and in selected groups of the family. Knowledge on the chemical and nutritional quality of the diet and of its individual components is equally important. Information related to food processing at the industrial level becomes important if a weaning food is to be produced commercially.

There are two approaches to improving nutritional status. One is to fortify a commonly eaten dietary staple (cereal, starchy roots, fruit, food legumes) with essential nutrients that are deficient in the usual diet. The other is to supply a dietary supplement that contains a portion of all essential nutrients to complement the basic diet. If the product is a weaning food, a number of industrial technologies are available to make a high-quality food. However, the socio-economic characteristics of the target population make it difficult to reach those most in need. It can be achieved, however, through education, demonstrations, provision of incentives, and improvement in the overall socio-economic situation (figure 1).

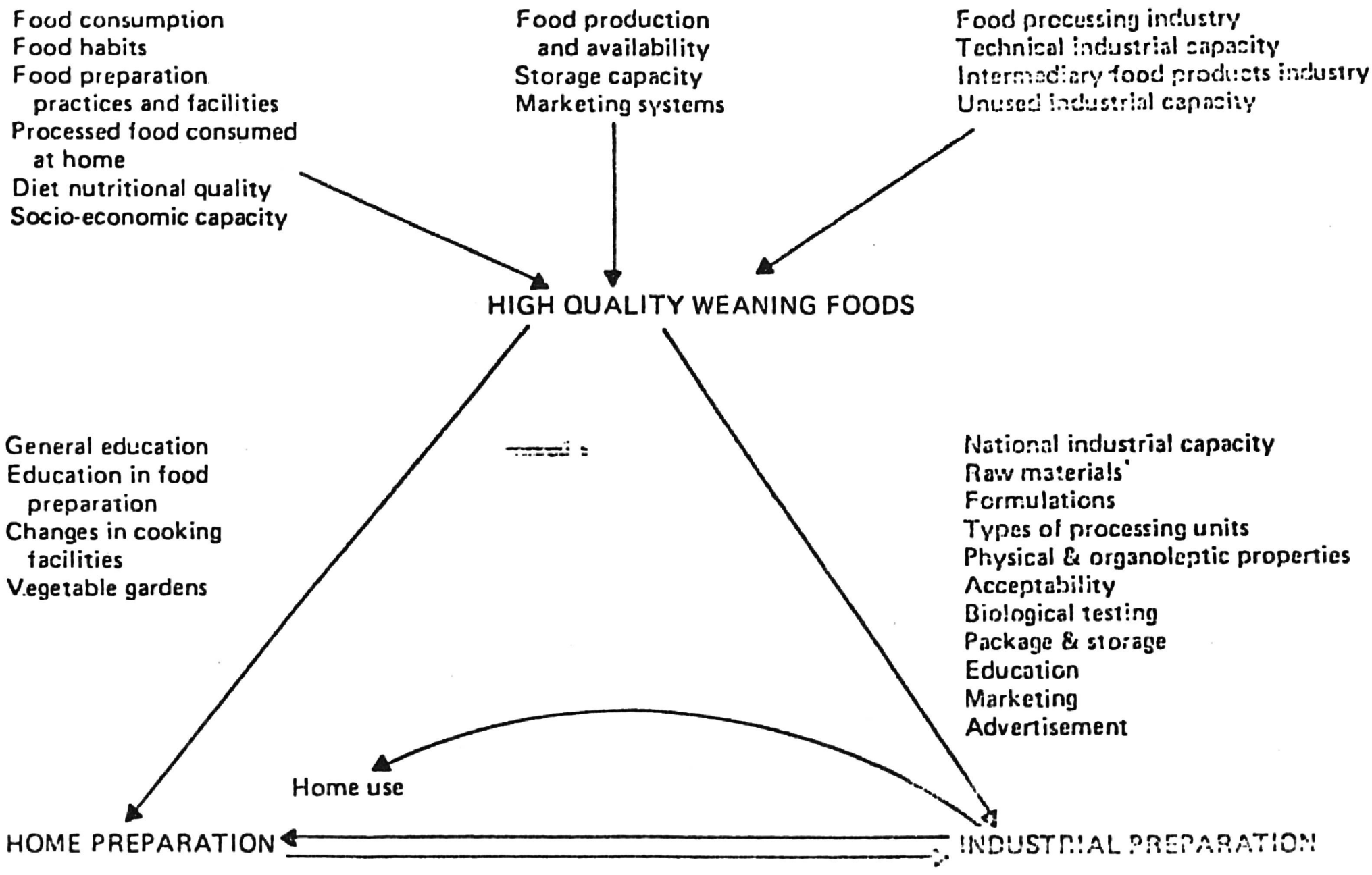

FIG. 1. Overview of the Components for the Development of Processed Packaged Foods

BACKGROUND INFORMATION

The Prevailing Food Consumption Pattern

As a first step in the design of weaning foods for home preparation or for industrial production, it is important to know, as quantitatively as possible, the food ingredient composition of the diet consumed by the target population. In general, the bulk of the diet is made by a specially processed cereal grain and a food legume. The cereal grain is often replaced by starchy foods, such as roots and plantain. For the small child, the main food offered is often either the main cereal grain consumed by the rural population or cereal grains known to be well accepted by the child. For example, in Guatemala, small children are given lime-treated corn tortillas or thin gruels made from rice, or bread made from sweet dough. Usually, and as early as two to three months of life, culinary fractions of the second most important food of the rural diet is given, such as the cooking broth of beans. Other food items, if available are included, and range from small amounts of animal food products to green vegetables. This kind of information can be very useful in designing weaning foods to be prepared at home or industrially.

As important as knowing which foods make up the diet is knowledge of food preparation practices at home so that the commercial producer will understand the organoleptic property and flavour acceptable to the consumer. Furthermore, knowledge of home methods may suggest how and when to introduce supplementary foods. An example is the supplementation of lime-treated cooked corn with whole soybeans. Likewise, knowledge of environmental conditions, kinds of water supplies, and cooking facilities provides insights on various properties the weaning food should or should not have. A possible sequence of guidelines on the above would be the following:

1. Carry out dietary surveys to determine the kinds of foods consumed, the amounts ingested, the frequency of consumption, as well as the general characteristics of the diet in terms of its major components, and their availability from the agricultural point of view.
2. Attention in the previous quideline should be given to the diet consumed by the *specific* population group where the food in question is needed.
3. Information is required on the reasons for the dietary practices of the population in relation to food patterns.
4. Knowledge is necessary about the food preparation processes used at the home level.
5. Equally important is understanding of the function of foods in the diet, the flavour preferences, texture, and other factors important in its acceptance.
6. It is also of importance to determine the nutritional quality of the diet from the chemical and biological point of view.
7. Attention must also be given to the cost of the food in relation to what is expected from it; i.e., whether to feel full, to obtain pleasure, to provide strength, or for socio-economic reasons.
8. Special attention should be given, particularly in rural areas, to the sanitary conditions around and in the house and during food preparation. Water supplies must receive particular emphasis.

Availability of Potential Food Materials

Food ingredients for the formulation of high-quality, nutritious foods may come from four sources.

From agricultural production. Food consumption surveys reflect the main agricultural food products of a country and these are usually selected to be ingredients of weaning foods. Availability of the cereal grains is significantly higher than that for other food items, and food legumes are seldom used because they are scarce and costly. However, legumes seem to be more adequate for weaning foods prepared at the home level. Other cereal grains besides the main staple can, however, be used, depending on availability and cost, and production feasibility in the country. Other food products should be considered, particularly those from animal origin, such as milk, and fruits and vegetables. For example, plantain, bananas, and potatoes are not often used, although they offer interesting opportunities.

There are sometimes foods with good potential for use in weaning foods in a country, but because production level is low, they are not readily available and are not used. These products could be promoted. Likewise, high-yielding cereal grain varieties with characteristics that make them unacceptable for direct use could be processed for weaning food development.

Agricultural by-products. Besides the main crops produced, other agricultural products must be considered, in particular those that are better sources of protein, such as the oilseeds. However, these seeds are generally used for their oil, and the residue after processing for oil is not of a quality adequate for human consumption. Some oilseeds, such as soybeans, do not have to be processed industrially in order to be used in the preparation of weaning foods, although they must be processed for consumption.

Other agro-industrial by-products include those from the cereal grain industry, particularly rice and wheat, e.g., broken rice and brans, and they are good sources of nutrients and usually inexpensive.

Intermediary industrial products. Although the by-products of the agro-industries could be considered intermediary food products, they often lack the quality required for acceptability. The presence of an industrial

capacity to produce intermediary food ingredients is very important, and at present the most common is that for wheat flour. This is significant because otherwise an industry set up to make weaning food has to produce all of the ingredients beforehand.

New food sources for a particular country. A variety of new food sources are likely to be available locally or could be locally produced, but because of low productivity, undesirable factors, and lack of knowledge for their production and processing, they have not been tried.

Basic Nutritional Information on Potential Products

The number of products used in the development of weaning foods is relatively small. The cereal grains used have been corn, rice, wheat, and sorghum; food legumes have included common beans, field beans, chickpea and pigeon pea; oilseeds used are mainly soybeans and to a lesser degree, peanut, cottonseed, and sesame; starch-rich foods include cassava, yams, potato, plantain, and banana. Therefore, information should exist on the basic nutritional data for these materials.

Calorie sources. Sources of carbohydrate calories to be used in weaning food formulations include starchy foods, such as cassava, yams, plantain, and bananas that contain little protein. Energy sources with oil and protein include peanuts, soybeans, and sesame seed. These products contain proteins with good amino acid balance, although they are limited in lysine and sulfur amino acids, which must be corrected during formulation. The protein quality and digestibility are high, with values ranging from 80 to 95 per cent.

Protein sources. Because of the amounts used in formulations, cereal grains can be considered to be protein sources, although the percentage of protein is low because of deficiencies in lysine and tryptophan.

The oilseed flours, once the oil or the carbohydrate is removed, are protein sources. In general, the amino acid pattern is similar to that of the original seed, but protein concentration is high (table 1).

Other nutrients. The ingredients used to prepare weaning foods or other products contain other nutrients such as minerals and vitamins, whose content should be determined for better background information before proposing mineral/vitamin supplements. Sometimes, even though specific nutrients are present, they are not totally available to the organism, or other organic components, for example phytic acid and tannins, intefere with their biological utilization.

Antiphysiological factors. Most potential weaning food ingredients contain antiphysiological factors. These are often destroyed or inactivated by appropriate processing, and others are, or should be, reduced to acceptable levels. Table 2 indicates the antiphysiological substances of interest in the main products used in the preparation of weaning foods, and shows how they are inactivated or partially removed.

TABLE 1. Amino Acid Deficiencies in Various Products Used in Weaning Food Preparations

	Deficient	Source
Cereal grains		
Whole corn	Lysine - tryptophan	Methionine
Degerminated corn	Lysine - tryptophan	Methionine
Rice (white)	Lysine - threonine	Methionine
Wheat flour	Lysine	–
Sorghum	Lysine	Methionine
Cereal grain by-products		
Corn germ	Methionine	Lysine
Rice polishings	Methionine	Lysine
Wheat middlings	Methionine	–
Oilseeds		
Soybean protein	Methionine	Lysine
Cottonseed flour	Lysine	–
Sesame protein	Lysine	Methionine
Peanut	Lysine - methionine	–
Other		
Yeast	Methionine	Lysine
Leaf protein	Methionine	Lysine
Food legumes		
All kinds	Methionine	Lysine

National Industrial Capacity

In programmes designed for the development and production of weaning foods at the industrial level, it is necessary to have a general, and in some cases the specific capacity, that the local food processing industry has in using equipment resources to manufacture a constant supply of foods, and the technical capacity to produce the kinds of weaning food ingredients meeting quality specifications for human consumption. Two approaches are therefore needed: (i) to discover any unused capacity to manufacture ingredients, and (ii) to ensure the technical capacity to produce quality foods.

Storage and processing of cereal grains. Two areas are important. One is the national capacity to store grain products without loss of quality from insect attack and fungi.

TABLE 2. Antiphysiological Factors Present in Ingredients for Weaning Foods

	Antiphysiological Substances	Processing
Food legumes	Trypsin inhibitors	Inactivated by heat
	Haemagglutinin	Inactivated by heat
Soybean	Trypsin inhibitor	Inactivated by heat
	Urease	Inactivated by heat
Cottonseed	Gossypol	Reduced during oil extraction
Lupine	Alkaloids	Reduced during processing

In the case of common beans, storage problems often arise in the humid tropics because of lack of adequate storage conditions. Poor facilities result not only in physical losses of grains, but also losses in nutritive value and in organoleptic and cooking characteristics.

The second has to do with the capacity to produce, under sanitary conditions, by-products from cereal grain milling that could be used in weaning food formulations, such as broken rice, rice polishings, wheat and corn germ, and gluten.

Industrial sources of protein. The protein source for most weaning foods is derived from oilseed processing plants, whose primary objective is to produce oil with little regard to the nutritional, organoleptic, and bacteriological quality of the meal, or of the product remaining after oil extraction. Although the industry may have the technical and physical capacity to produce a flour with acceptable quality, often it is not attractive economically. An example of this has been cottonseed flour for human consumption, which requires appropriate processing to meet quality specifications and remove the gossypol.

Relationship between agricultural production and the food industry. This relationship is essential in programmes designed to produce high-quality foods. It exists for some food industries, such as processors of tomatoes and citrus fruit, and for oil production, but not for other high-quality foods. Some possible mechanisms to relate agriculture to industry and promote the industrial production of weaning foods is shown in table 3.

DEVELOPMENT OF THE WEANING FOOD CONCEPT

Two avenues are open for the development of weaning foods, applicable at the home level or for industrial production. The first is the enrichment of traditional foods, or supplementation, and the second is the development of a "new food" or high-quality protein foods. For home preparation and for industrial production it is necessary for a country to have an ongoing industry manufacturing the traditional food. For the second, it would be necessary to develop or set up a new industry in most cases, or take advantage of any unused processing capacity of the country.

Food Formulation

Supplementation of basic staple foods. The rationale behind supplementation of a staple food is that its quality is nutritionally poor because it is deficient in amino acids and other essential nutrients. These deficiencies can be corrected through the addition of small amounts of foods that are rich sources of the nutrients limiting the nutritional utilization of the staple food. The amounts added should be enough to increase changes in nutritional quality without affecting the preparation, functional properties, or organoleptic characteristics of the product. Examples include the addition of soybean protein to corn or wheat for tortilla and bread production, respectively. The nutrients added can be protein and energy as well as minerals and vitamins (table 4). There is often a small increase in protein content and quality associated with protein supplements.

TABLE 3. Mechanisms to Promote the Industrial Production of Weaning Foods

Mechanism	Raw Material	Intermediary Products	Final Products
Promotion of agricultural production	×		
Financing feasibility studies		×	×
Equipment purchase		×	×
Credit	×	×	×
Technical assistance	×	×	×
Promotion of consumption through education, advertisement, and quality control		×	×
Promotion of intermediary consuming industry		×	×

TABLE 4. Minimum Amounts (in Per Cent) of Various Supplementary Proteins Found to Improve the Nutritional Quality of Cereal Grains and Starchy Foods

	Egg	Casein	Meat	Fish	Soy Protein	Soy Flour	Cottonseed Flour	Yeast	Beans	Milk
Corn	3	4	4	3	5	8	10	3	20	10
Sorghum	–	–	–	–	–	8	–	–	–	–
Rice	–	6	–	6	–	8	12	8	15	12
Whole wheat	–	4	–	–	–	6	10	4	–	6
Wheat flour	–	6	–	–	–	10	12	6	–	10
Plantain	–	–	–	–	–	–	–	–	30	–
Cassava	–	–	–	–	–	–	–	–	30	–

Specific Guidelines for Supplementation

- The food selected for supplementation must be the major component in the usual diet.
- Food intended to be supplemented must be produced industrially, although not in the case of home-prepared weaning foods.
- Supplementation should be done by adding those nutrients lacking in the particular food, but at levels required to improve the nutritional quality of the whole diet.
- If possible, other nutrients not deficient in the particular food but lacking in the diet, should be added.
- Processes used at home for the preparation of a selected food should not affect the biological utilization of the added nutrients.
- Addition of nutrients must not change flavour, texture, colour, and if possible, not interfere with processing conditions normally used.
- The nutritional value of the supplement as well as its efficacy in improving the nutritional value of the diet must be assured by running chemical and biological assays.
- The addition of nutrients should not interfere with the efficiency of utilization of other nutrients present in the food itself or in the diet as a whole.
- Preparation of the supplement, and if possible that of the supplemented food, must be carried out at an industrial level to assure a homogeneous product.
- Chemical and biological quality control tests must be devised and applied periodically in order to guarantee the effectiveness of the supplement, as well as that of the supplemented food.
- Processing conditions at the industrial level to prepare the supplement must be constantly monitored in order to maintain desirable chemical, sanitary, and nutritional characteristics.
- The cost of the final product must be within a range that the consumer can afford.

Balanced food mixtures. To achieve balance in combining foods, advantage should be taken of the complementary effect of mixing two or three protein sources. A complementary effect takes place when the amino acids limiting the quality of one ingredient are provided by a relative excess of these same amino acids in another ingredient, which results in an increased quality above that of any single ingredient. Table 5 summarizes examples of the concept, using a variety of potential ingredients. The addition of other foods to the mixture to give maximum complementary effect results in improved quality of the diet.

Supplementary mineral and vitamin mixtures. With either approach, the supplementary or complementary method, and for weaning foods, it would seem advisable to add a supplement of minerals and vitamins, which may or may not be based on the diet consumed daily. It is recommended because it implies a more efficient utilization of the weaning food, which itself could induce micronutrient deficiencies if these are not available in the basic rural diet.

Commodity specifications. There is at present no set standard for the chemical composition of weaning foods.

TABLE 5. Optimal Mixture by Weight of Two Ingredients for Weaning Foods

Rice/beans	40/60
Oats/beans	60/40
Wheat/beans	50/50
Wheat gluten/beans	60/40
Bread/beans	60/40
Egg/beans	50/50
Sesame/peas	40/60
Maize/milk	50/50
Opaque-2 corn/milk	65/35
Corn/soybean	70/30
Corn/cottonseed	60/40
Soybean/beans	40/60
Sesame/yeast	80/20
Cottonseed/yeast	60/40

Protein content is quite variable (16 to 28 per cent) in current industrially produced weaning foods. Milk could be used as a model. As a rule, low protein content should have a higher quality than required when protein content is greater. Because the amounts to be used are relatively small, and as they will play the role of an only food, or a supplemental food, higher nutrient density is recommended. The commodity should therefore have consistent nutrient content and quality specifications, including bacteriological quality. Likewise, physical characteristics should be considered, such as dispersion properties, flavour, texture, and ease of consumption. Furthermore, the ingredients should be well defined for quality control purposes to ensure standard specifications of the final commodity. For highly nutritious foods these are:

1. The materials to be used in the formulation should be locally available and must be part of the normal agricultural production of the country.
2. Processing conditions for crops must be well established and a quality control for the industry is necessary to keep the product within the specifications for human consumption.
3. If the material to be used in the formulations is not a conventional source of protein for human consumption, chemical, toxicological, and nutritional studies in animals must be carried out in order to assess their safety for human consumption.
4. Quality standards must be set up for the new sources of food used in the formulation, as well as for the formulated food itself.
5. To assure adequate protein content, formulation of the food should be based on the amino acid content, and then tested in biological assays in animals and then in human subjects, if possible.
6. Other nutrients, such as calories, vitamins, and minerals must be added according to the deficiencies in the diet and for the selected population group.
7. The formulated food should preferably be designed according to the dietary habits of the population selected, and must also be capable of being consumed in different forms.
8. The preparation of the formulated food should be carried out by a private enterprise and must compete in the market as a regular food product.
9. It is important to have alternatives in the preparation of the formulated food as far as the raw material is concerned.
10. Packaging should be carefully chosen not only to keep the desirable characteristics of the product, but also to present a good image to the consumer.

DEFINITION OF INGREDIENTS

Ingredients should be described in terms of the raw materials used, the processing technique employed to produce it, and the chemical and nutritional value it should have. It should also include bacteriological quality as well as functional properties. Quality control measures should be established for purposes of meeting requirements of the product.

PRODUCT TESTING

The process of testing the product is important, particularly for those situations where the ingredients in the food are so-called "non-conventional", for example, single-cell protein. Testing involves various activities: chemical analyses and amino acid content; biological evaluation in experimental animals; supplementary effect on basic diet; storage stability; tolerance tests, and acceptability trials.

Chemical composition. Chemical composition should be tested for levels of moisture, protein, ash, crude fibre, fat and carbohydrate, and the energy value of the food should be known. It should also include acceptable maximum levels of residual antiphysiological substances.

Amino acid content. This should be part of the commodity specifications and be limited to the essential amino acids. It should indicate any amino acid limiting the quality of the product for quality control purposes.

Biological quality. Because of the difficulties of evaluating biological quality in humans, animal studies should be conducted. The laboratory rat, used in a variety of methods (NPR, NIG, NPU), is suitable for such a purpose. Testing for digestibility of the protein is also highly desirable. If non-conventional sources are used, long-term studies are recommended, particularly if the product contains small amounts of antiphysiological substances such as gossypol in cottonseed flour. Biological evaluation should also include supplementary studies of the basic diet as a means to improve or correct any nutritional deficiencies it may have.

Storage stability. Because these products are manufactured to serve as weaning foods in urban as well as in rural areas, careful storage is essential. In the latter, environmental conditions of high relative humidity, high temperature, and exposure to the external environment make storage stability tests mandatory, as these factors may all lead to the development of caking, off-flavours, and insect contamination.

Addition of preservatives. This is sometimes desirable to reduce or avoid the development of off-flavours, losses of vitamins, or formation of substances that could induce nutritional problems.

Packaging materials. Packaging materials serve to preserve the packaged food from external physical and biological

TABLE 6. Selected Weaning Food Case Studies

Product	Ingredients	Processing	Form	Marketing	Package	Package Size	Years on Market
Incaparina (Guatemala)	Processed corn-cotton-seed flour, vitamins minerals	Mixing of ingredients	Mixed processed	Commercial and Government	Paper plastic	460 g 75 g	22
Maisoy (Bolivia)	Corn, whole soy	Extrusion	Flour flakes	Commercial and Government	Plastic box		7
Bienestarina (Colombia)	Rice, soy, milk	Extrusion	Flour	Government	Plastic	1 kg	10
Chicolac (Bolivia)	Rice, milk	Spray drying	Flour	Commercial	Plastic	500 g	1
Torti-Rice (Costa Rica)	Lime-treated corn, soy	Mixing	Flour	Commercial	Plastic		7

factors as well as to carry appropriate messages to the potential consumer. It is best to package a processed product rather than a raw one; since with the latter there is the danger of insect egg development within the package in addition to the rapid development of off-flavours. Insects can pierce the package material and expose the product to the external environment. Packaging materials commonly used include plastic, paper with an internal covering of plastic cellophane, or closed paper boxes.

Acceptability tests. These could be carried out for periods of two to four months in schools or other institutions or directly in households.

INDUSTRIAL PRODUCTION

Once the above problems have been solved, methods of production should be established. If the materials are already processed, the production operation will involve only mixing and packaging. On the other hand, if the products are not fully processed, or are still raw, processing must be carried out. Various options are available. One is drum drying, often used for baby food products in developed countries; extrusion cooking seems to be the preferred technology today, and finally, spray drying is sometimes appropriate. There are various other possibilities, depending on specific situations. For example, if one of the ingredients is raw it can be roasted and then ground, or extruded and ground and then mixed with the already processed ingredients. Table 6 illustrates processing and marketing of some successful products.

The investment in processing is one of the most important considerations for developing weaning foods in developing countries because of the high cost. However, alternatives are available.

1. *Unused national industrial capacity.* Unused industrial capacity may exist in the cereal milling and processing industry as well as in other food industries. For example, there is a situation in which a spray dehydration plant has a larger capacity to produce powdered milk than it actually produces because raw milk production is not sufficient. Hydrolyzed cereal flours can be mixed with liquid milk and processed together. Soy milk and cow's milk could be combined in a similar fashion.
2. *New industrial development.* Such industries have been developed, but, as indicated previously, they need a large capital investment.
3. *Quality control.* A very important aspect in the industrial production of weaning foods is quality control, which should be integrated with the actual production of the food

MARKETING

The final action is marketing of the product. There are various ways that have been tried or are now under way. One is the distribution of the product by governments in various nutritional programmes they may have. The products are either produced by government agencies or by private industries who sell them to the government. A second approach is private production and marketing in

the free market, or part may be purchased by the government and part may be released to the retail market. The cost of the product is an important consideration, for both markets must be satisfied. In any event, the marketing of the product should be done with demonstrations applicable to the conditions in developing countries. The product should be advertised by the press, radio, and television. Home economics extension work to educate consumers is essential.

Some guidelines for advertising are:

Advertisement of the product should be carefully planned, taking into consideration the following points:

1. Try to give the product prestige through adequate packaging and place it in the market with other acceptable foods.
2. Run acceptabiligy tests in the laboratory, then at an institution, with individual families, and finally at the community level.
3. Advertisement must be directed toward the specific population groups for whom the food is intended.
4. In the case of weaning foods, it is important to recognize the influence of the mother in acceptability of the product in terms of flavour and nutritional properties.
5. Run stability tests under different climatic conditions, in order to avoid undesirable changes in texture, flavour, and nutritional quality of the product in different locations.
6. Ease in preparation should be an important aspect of creating a new food.
7. Price of the product should be as low as possible to fit the purchasing capacity of the consumer, but not to make the product a food for the poor (prestige).
8. Programmes must be instituted on how to prepare the product under the conditions prevailing in the home, how to use it, and any limitations should be indicated.