# THE DATA REQUIRED FOR A FOOD DATA SYSTEM



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In the animal feed industry the statement is often made that a feed is not worth anything in spite of its chemical composition until it reaches the stomach of the animal. It is at this time that the chemical composition of the feed and the nutrients it delivers begin to have some nutritional meaning. The same statement can, of course, be made about foods for human consumption. The reverse statement is also true, that a food or feed that is readily consumed by humans or animals should carry the nutrients it originally contained, or at least the maximum possible, after going through the food chain from production to consumption, so that the organism can use them for growth, development, and other physiological functions. The main difference is that feeds, in contrast to foods, if they are processed, go directly to the animal, usually as balanced diets, while humans obtain the nutrients from foods consumed in a random way. Foods that have been industrially processed are often further processed at home before being eaten.

This paper will propose the development of an International Network of Food Data Systems based on the concept of the food chain as a means of establishing what must be in the data base, of achieving a better identification of the food, of determining at what point the constituent should be measured, and of taking into consideration all processing operations as carried out in developing and developed countries. The first section of the paper deals with the events taking place from production of foods to their consumption. The second section considers the significance of the factors influencing chemical composition in each link of the food chain. This will facilitate knowing how constituents react to production factors as well as to storage and processing. The third section relates to the proposed structure of food composition tables, ending with a brief section on the type of data required for the data system.

## THE FOOD CHAIN

In order to discuss the topic of the data required for a food data system and to obtain and gather information about foods for a data base, it seems worthwhile to look first at the significant factors that determine, affect, or are responsible for, the chemical and nutrient composition in the food supply as it comes from agricultural production or has been developed from raw materials to meet nutrient needs, convenience, and other demands of the population. It should be indicated, furthermore, that the careful identification of the foods is as important as the quantitative values for the constituents if the data are to be of value. The data required are not altogether static, because they change with industrial development, income, and population behaviour. Thus, it appears that to meet these requirements, the food chain concept can be of much value. The basic food chain, however, may follow any one of the schemes shown in figure 1.

Foods produced with a certain chemical composition usually undergo storage for marketing or processing purposes, and as such they are further processed at home before consumption. This, of course, is not true for all foods, but most undergo home processing before they reach the table.

A second option is for the food to be processed soon after harvest, such as vegetables that are canned or frozen. They remain in storage under standard or fixed and optimum conditions before being purchased, and then they are cooked before consumption. In developing countries post-harvest handling and inefficient storage facilities for marketing induce significant changes in constituent concentration. When such foods are analyzed, they seldom represent what people actually purchased.

The third possibility consists of storing grains after harvest, followed by processing to a raw or processed flour that is also stored, and when purchased, it is subjected to home-cooking before consumption. Two examples of this are shown in figure 2 for wheat grain processed into bread, or for corn processed into tortillas. Nutrient composition data on the raw grains are, of course, very useful; however, the chemical composition of the food *as consumed* is even more important and meaningful.

A more complex situation is shown in figure 3 for food legume consumption. As shown in the figure, a large number of processing steps are followed to make beans edible, and what makes the problem more complex is that the processing conditions are such that using chemical composition data based on the raw materials to determine nutrient intake or nutritional quality will probably give a misleading picture of the final product. Gross nutrient

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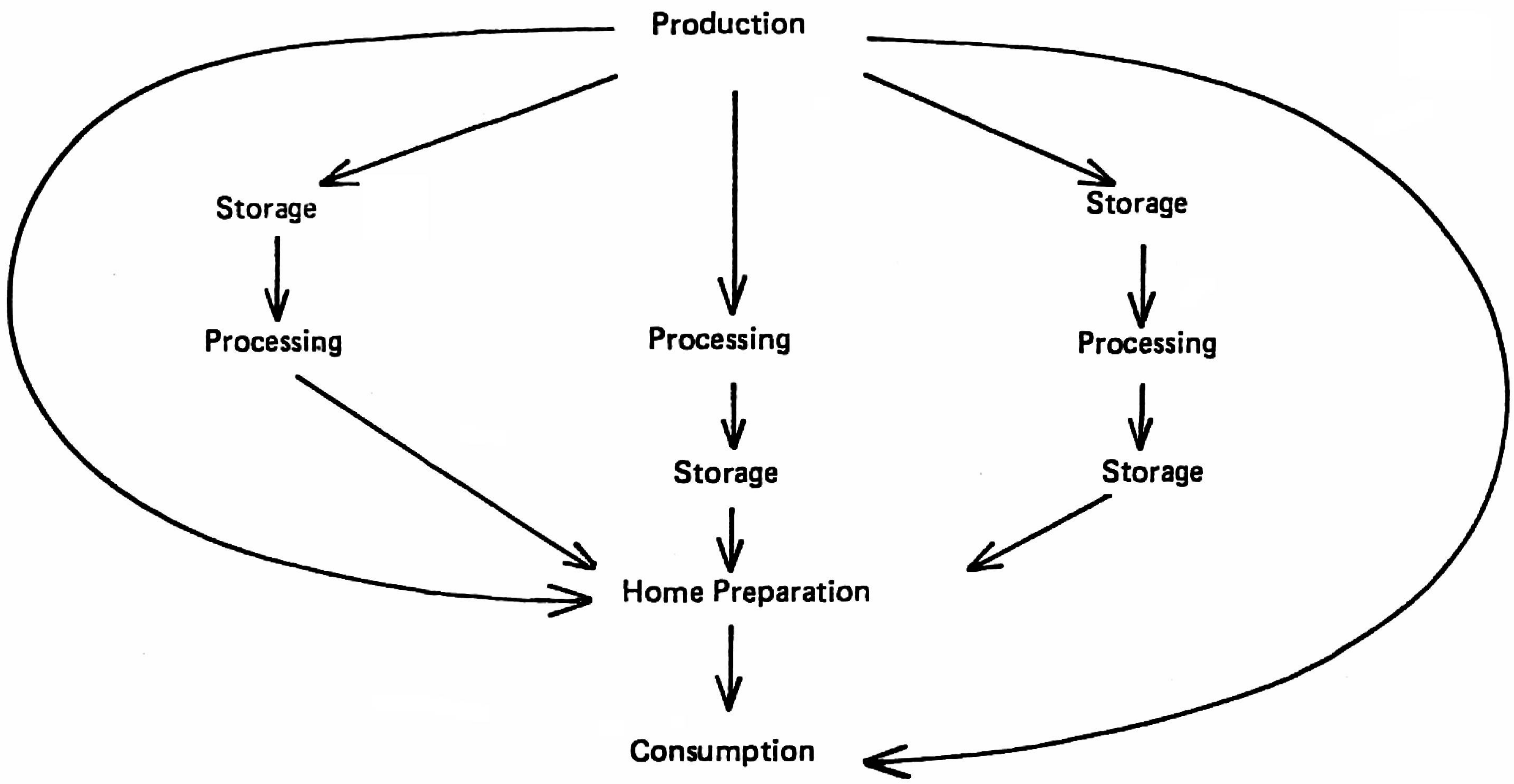


FIG. 1. Possible Routes from Production to Consumption of Foods

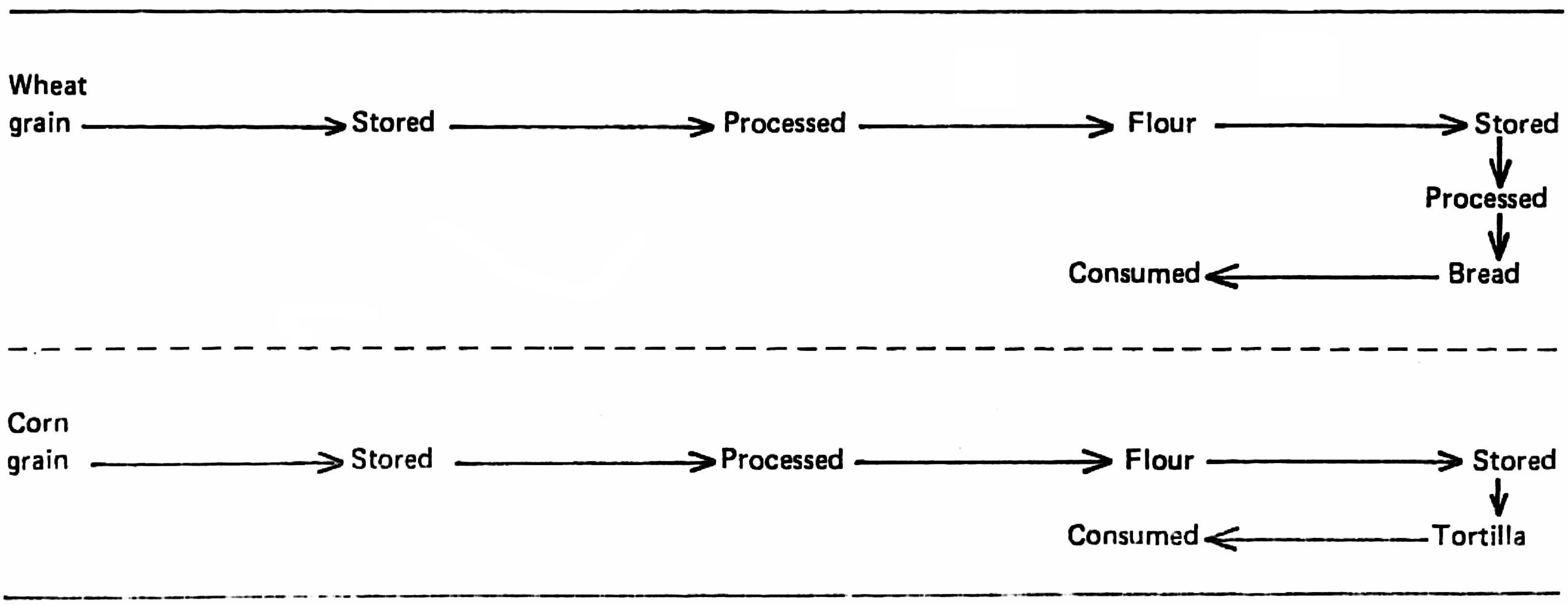


FIG. 2. Examples of Operations Involved with Selected Cereal Grains

including nutrient availability, may reveal a completely different picture. Biological values of diets from animal assays as compared to values calculated from food composition data are very different. This has led to the conclusion that animal data are not applicable to human needs, while part or most of the difference lies in the fact that the food values used for calculation are chemical data measured in the raw food products. Therefore, nutrient intake data often overestimate many constituents, and because of insufficient data the intake of some other nutrients is also overestimated. All these links in the food chain affect, to any [illegible], the [illegible]

TABLE 1. The Food Chain, Outcome, Factors Affecting Outcome, and Potential Uses of Information

| Food Chain | Outcome | Factors Affecting Outcome | Uses |
|---|---|---|---|
| Production | Nutrient yield or content | Genetic<br>Agronomic<br>Environment<br>Feed quality | Plant breeders<br>Animal production<br>Food scientsts<br>Nutritionists<br>Economists<br>Food and nutrition planning |
| Storage | Nutrient losses | Temperature<br>Relative humidity | Food scientists<br>Marketing<br>Regulatory agencies<br>Industry |
| Processing (industrial) | Nutrient loss<br>Changes in bio-utilization<br>Reduction anti-physiologic factors | Temperature<br>Time<br>Moisture<br>pH | Food scientists<br>Engineers, technologists<br>Regulatory agencies<br>Industry |
| Storage | Nutrient content<br>Stability<br>Nutrient loss | Temperature<br>Time<br>Packaging system<br>Relative humidity | Food scientists<br>Industry<br>Regulatory agencies |
| Processing (home) | Nutrient loss<br>Changes in bio-utilization<br>Reduction of toxic compounds | Temperature<br>Time | Nutritionists<br>Dietitians<br>Food scientists |
| Consumption | Nutrient intake and availability<br>Health condition<br>Nutritional state | Nutrient content<br>Nutrient availability<br>Nutrient intake | Nutritionists<br>Dietitians<br>Medical profession<br>Consumer |

tion and availability of the ingested food and sometimes even the acceptability to a point at which it cannot be considered a food. Furthermore, the factors in the links interact with each other from production to consumption.

## FACTORS AFFECTING NUTRIENT CONTENT IN SPECIFIC LINKS OF THE FOOD CHAIN

The factors considered important in establishing the nutrient content of foods, for which experimental evidence is available, will now be discussed. These are summarized in table 1, which also shows the main effect on nutrient content of the factors affecting the specific link in the food chain, some of the factors responsible for the outcome, and the user(s) of the information.

*Production.* This term is usually associated with amounts per unit of land, but many breeders use terms such as calories per hectare or protein per hectare. In this paper, production will be discussed in the latter context, that is, nutrients per hectare (yield) or nutrients per 100 g. Consideration of chemical composition in relation to production is important because of advances made by agricultural research in introducing new varieties and agricultural management practices for vegetable foods, as well as the introduction of modern, intensive animal production systems for milk and other animal products, including those from poultry, swine, and cattle, that affect product composition.

Factors affecting nutrient content in vegetable products from time of harvest are given in table 2. The table also shows the factors affecting animal food products. A number of examples can be given on the effect of the above factors on chemical composition or nutrient content. The problem, however, is to [illegible] and frequency these factors affect composition, and [illegible] a

TABLE 2. Factors Affecting Chemical Composition of Vegetables and Animal Food Products

| *Vegetables* | *Animal* |
|---|---|
| genetic make-up | genetic make-up |
| agricultural management practices | physiological state and sex |
| environmental factors and soil | feed quality and feed intensity |
| physiological state (maturity) | season |
| vegetable part (leaves, flower, seeds) | growth additives |

large number of analyses will compensate for the variability found. These possible differences are probably not too significant in food consumption patterns when great varieties are available, but they may be important when the numbers of items consumed are few, as occurs in developing countries. Information on the sample of food analyzed should be as complete as possible for a good data base.

*Storage — raw products.* There are many studies in which the effect of storage on nutrient content has been examined. The problem is that most studies have concentrated on the major nutrients and only a few on the minor ones. If storage conditions are ideal, the chances of finding changes are low; however, ideal storage conditions for most food crops or animal foods are often non-existent and changes do take place.

The main factors related to storage include moisture in grain, temperature during storage, relative humidity, and time. Maturity of fruits and vegetables is also important. If these factors are not controlled, changes in chemical composition induced by biochemical reactions will take place in the stored food, favouring bacterial and fungal growth, particularly in grains, and reducing the nutrient content. Storage may affect nutrient content indirectly by inducing physical changes in the grain structure that will influence milling losses and require higher heat processing conditions. The best example is the common bean. Methods of post-harvest handling must be included in the identification of the sample. Again, the point is the extent of the change and whether such a change will make a difference once a number of analyses have been made. The number of analyses thus becomes an important issue.

*Storage — processed food.* Storage of processed products also deserves attention. Processing is carried out to make the food edible and to stabilize it before consumption. Storage under cold conditions or in sealed containers with no or minimum gaseous exchange and protection from light may induce little change. However, due to the cost of packaging materials in developing countries, plastic or cellophane materials are used, particularly for grain flour and other processed products. An example of the effects of poor storage conditions on stored soybean flour is given in table 3. The samples analyzed were drawn from different locations and classified according to colour. It is of interest to see the loss in nutritional value of the different coloured samples. An additional point is that often processing of foods may favour their deterioration in storage if conditions are not appropriate and controlled because of the chemical changes that took place during processing.

*Processing.* This step refers to industrial food processing, a factor in the food chain that has been studied extensively for its effect on nutrient composition and nutritive value. Besides the transformation or stabilization of food through processing operations, the concept also includes those activities related to food product development for all population groups as well as for particular segments of the population, e.g., baby foods, milk substitutes, and the like. For classification purposes, processing has been divided into five methods, as described in Table 4, although it is realised that there is no clear-cut difference in many of the processing operations. Mechanical treatment refers to the removal of physical fractions, of which cereal grain milling is the best example. Hot and cold treatment is another set of processes, with temperatures varying from below zero in freeze-drying to higher than 100°C for varying amounts of time. Chemical treatment is important because in addition to improving functional properties, it adds nutrients such as Na or Ca. Finally, fermentation and germination processes, as well as irradiation, alter nutrient composition and availability. Mechanical treatment probably affects overall chemical composition of the primary food more than any other process. The other processes affect vitamins and nutrient availability more, but structural changes can and do take place. The Maillard reaction is classical in this respect, usually associated with losses of amino acid availability. However, chemical constituents also develop that may cause undesirable effects.

*Home-processing.* Although the home is not usually considered a link in the food chain, many foods are processed at home before consumption. Since this is the last step before the food is ingested, it would seem

TABLE 3. Effect of Storage on the Nutritive Value of Soybean Flour

| Soybean Flour Colour of Sample | Available Lysine g/16 gN | Protein Digestibility (Apparent) % | NPR |
|---|---|---|---|
| Light yellow | 5.82 | 86.6 | 3.89 |
| Yellow-brown | 5.34 | 88.7 | 3.43 |
| Light brown | 4.45 | 83.5 | 2.58 |
| Dark brown | 1.78 | 26.1 | 0.80 |

TABLE 4. Tentative Classification of Processing Operations on Nutritional Content of Foods

| Treatment | Process |
|---|---|
| Mechanical | Milling - peeling<br>Size reduction - grinding<br>Oil extraction - protein and carbohydrate concentrates<br>Packaging |
| Heat | Pasteurization - canning - toasting<br>Extrusion - drum drying - spray drying<br>Blanching - frying - popping - baking<br>Sterilization |
| Chemical | Lye (peeling) - protein concentration<br>Lime - bleaching - salting - curing<br>Oil extraction (solvent) - smoking<br>additives |
| Biochemical | Fermentation - germination - enzymatic |
| Physico-chemical | Irradiation - microwave |

appropriate and logical that all food composition tables be based on foods as consumed; that is, if the food is consumed raw, the analysis should be on the raw product, and if processed at home, or directly from industrial processing, analysis should reflect this. This is not yet the case in most food composition tables from developing countries, many of which were developed at least 35 years ago. Food processing at the home level introduces additional difficult questions to resolve for an International Network of Food Data, since cooking may mean anything from unsophisticated heating with wood in clay cooking utensils to microwave ovens. It is difficult to say which of the two extremes is less damaging to the constituents in the food, a question suggesting that a project such as the one being discussed will require research activities in this and other aspects. An additional question concerns the percentage of edible portion on the one hand, and measurements of food intake on the other. These may be standardized in developed countries, but certainly there are significant deficiencies in this respect in developing nations.

This section pointed out the factors to be considered for the data base as well as for data sources. As much as possible should be known about the identification of the food and what happens to it before it reaches the mouth of the individual.

Scientific publications are continuously being written by those scientists particularly interested in one of the links of the food chain. Such publications could, therefore, serve as data sources, particularly if the foods being analysed are well described and identified. Food quality control laboratories are also sources of information, especially for processed foods.

## A POSSIBLE STRUCTURE FOR THE INTERNATIONAL NETWORK OF FOOD DATA SYSTEMS

Based on the information discussed in the previous section, the International Network of Food Data Systems might therefore be structured on the basis of the food chain, with emphasis on those steps in the chain known to be more influential in determining or affecting nutrient composition. These are: production of the primary food; processing, which would include primary processed foods, foods developed for all and for specific population groups; product ingredients, such as protein isolates, specific carbohydrate or sugar sources, and oil products. Although storage is an important link in the food chain, changes in nutrient content may be minimal, particularly if properly stored after processing. Finally, home-processing may or may not be important, depending on the food and on the processing conditions used for food preparation before consumption. Nutrient composition data on the foods as consumed would be the best information that could be included in food composition data. The possibility of structuring food composition tables based on the food chain may appear to be too excessive in detail, repetitive, and expensive. However, this is not necessarily so, except for the beginning and end of the food chain, the primary product and the food as consumed. Furthermore, the number of entries for the same food within the processing link will be more because of the number and variability of processes, particularly because of international variations and because this link should include all new foods being developed and produced, such as baby foods, breakfast foods, meat and fish products, milk replacers and substitutes, party foods, and many other variations. Since the table is to serve multiple functions, including epidemiological studies related to diet quality, as much weight as possible should be given to processing and changes induced by it in nutrient content and availability. To give an example, a fried tortilla may have a composition different from a regular tortilla, but this change in composition may be less significant for epidemiological studies than the changes in fat composition.

A possible structure for a food composition table is shown in table 5. This has food items in food groups as the main classification. Sub-classification would include production or the raw food, separated on the basis of those factors that have a significant influence on composition. The same criteria are applicable to storage and even more so to processing. This is followed by storage of the processed food, ending with home-processing composition.

Developing food composition tables on the basis of what happens along the food chain may facilitate the gathering of the information as well as permit better classification and increase the number of users. Agricultural scientists, both plant and animal, economists, and others, would be interested in the foods as produced. Food scientists and technologists would be interested in all processing effects, while the medical profession, nutritionists, and dietitians would prefer analysis of foods as consumed.

The process of gathering data, of selecting and classifying the information, must receive particular attention because of significant differences in identification of food products as practised in developed and under-developed countries. In the latter, for example, meat cuts are not only different, but the types of animal are different, they are fed differently, and usually slaughtered at an older age. The classification may be based on fat content.

A second aspect to consider is the units used for results and how they may be expressed. In this regard, the meaning of "non-edible portion," of "serving," of "yield," and the like may be different. It would be important also to review conversion factors and how the sample was collected and how it was prepared for analysis. Since INFOODS is to be a dynamic process, present data may be used with the understanding thay they should change with time into a more standardized form, and coordinated efforts could be achieved through the preparation of guidelines for food collection, basic identification, and preparation, including chemical and biological methods of analysis.

## CHEMICAL DATA REQUIRED

Food composition tables have been extremely valuable within the science of food and nutrition. Because of the advances being made in the inclusion of additional nutrients in the recommended daily dietary allowances, the introduction of new vegetable cultivars in agricultural production systems, the newer technologies used to increase productivity from vegetable crops and animal species, the great number of foods being developed, and in processing techniques, it becomes necessary to develop, organise, and manage present food composition data as well as future developments in this aspect of food science and nutrition.

*Nutrients.* As expressed early in this paper, the decision on which nutrients should be included for each food item is the responsibility of the group of scientists attending this meeting. The reason for this is that the importance of a food item is different in various parts of the world. Similarly, foods are processed differently both industrially and at home. However, ideally, as much information as possible should be obtained for all foods, as in the food composition tables of the United States, listing

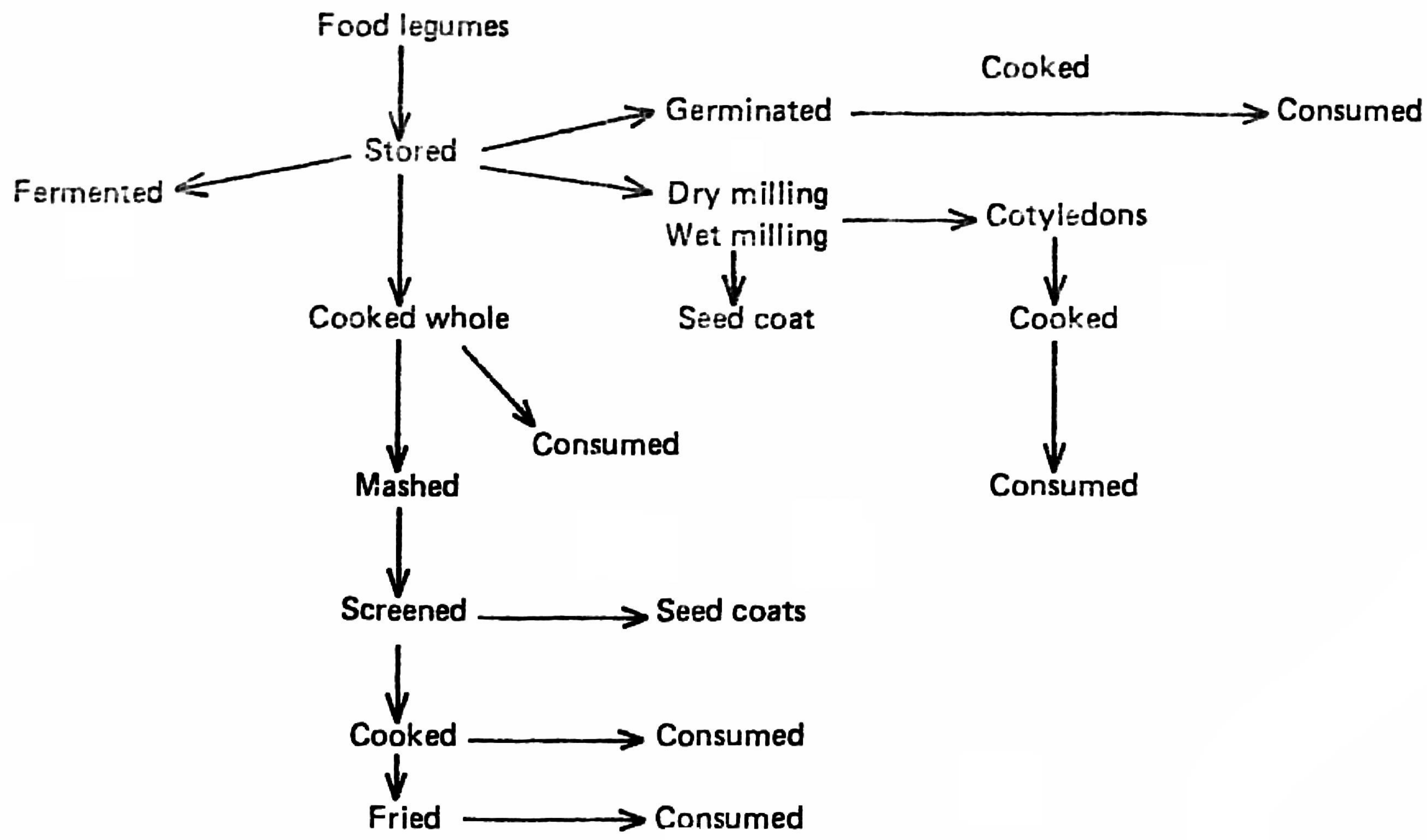


FIG. 3. Methods of Food Legume Processing and Consumption

TABLE 5. Example of Proposed Structure for Food Composition Table

| Identity | Corn | Food Item or Group | Other |
|---|---|---|---|
| Food Chain | Type | (Flint, dent, starchy, HQ) | |
| Production | Raw<br>Immature | (Whole grain)<br>(Stage of maturity) | |
| Storage of raw | Forms of storage | (Silo, sacks, other) | |
| Processing | Foods of whole corn processed by different techniques | (Corn grits, wet-cooked flour, whole corn flour, extruded, lime-cooked flour, etc.) | |
| Storage of Processed foods | Flour<br>Grits<br>Other | | |
| Home-cooking | Forms of consumption | (Tortillas, polenta, corn bread, arepas, etc.) | |

Each item from each step in the food chain would have its own composition.

seven items under proximate composition, nine vitamins, seven minerals, 18 amino acids, and the three main groups of fatty acids (eight saturated, four mono-unsaturated, seven polyunsaturated) as well as cholesterol and phytosterol.

Therefore, as far as the total number of nutrients per food item is concerned, newer additions to those already considered in the US tables should be incorporated as more data are derived from nutrition research. For example, crude fibre content should be detailed to include dietary fibre in those food items that are now being promoted as good sources of this component in vegetables, fruits, certain tuber crops, and cereal grain by-products. With respect to protein, although the appropriate conversion factor (N x factor) is used, an amino acid composition is also included, information on availability is lacking, a problem of importance for some foods when raw and even more so when processed. Thus, it would be advisable to include in the table available lysine and available methionine or sulphur amino acids.

It is well known that minerals from cereals, legumes, and other plant foods, in contrast to minerals from animal sources, are generally poorly utilized by man and other monograstric animals. Mineral availability is influenced by factors present in the food itself, such as dietary fibre, certain amino acids, phenolic compounds, and phytic acid, as well as by the interaction taking place between chemical components during processing operations. Although methodologies to assess mineral bioavailability are still being developed, food composition tables should already include some idea of mineral availability, particularly Zn and Fe, mainly for those foods of greater importance in the nutrition of a population. The inclusion of free fatty acids in tables to provide more data on fat value is a significant advance in the development of food composition tables. As with previous nutrients, more information should be provided on fatty acids that have been subjected to the effects of continuous processing, for example, deep fat frying. A similar argument applies to products susceptible to Maillard reactions.

*Antiphysiological substances.* There are a large number of foods known to contain antiphysiological substances that are supposed to be destroyed or inactivated during processing. The classical examples are food legumes, including soybeans, that contain trypsin inhibitors, haemagglutinins, urease, and others in particular food legumes. Values for these substances should be included, since there is evidence that they are still found in processed food, although at reduced level. Food legumes are also known to contain disaccharides responsible for flatulence.

Another group of compounds that may be responsible for poor utilization of nutrients includes tannins and phenolic compounds in beans, sorghum, and possibly in other foods such as cottonseed flour, that bind amino acids and may also bind minerals and inhibit enzymatic action.

In addition to the above, other factors included would be hydrocyanic acid content in cassava and cassava products, as well as the Maillard reaction that appears in certain products upon processing. Similarly, peptides such as glycylalanine resulting from alkaline processing of foods, and from the preparation of protein isolates, should be included. Oxalic acid and nitrate levels in vegetables are important. Finally, additives used in the preservation of processed foods should also be taken into account.

*Biological data.* Biological data are always missing in food data tables for human nutrition, while the opposite is true for animal feed composition tables. This type of information is useful, particularly if it comes from sound human studies. Therefore, protein digestibility should be incorporated, which, in turn, can be used to estimate amino acid availability from which a better biological value figure can be calculated. Biological data on vitamin A precursors and on iron availability should also be provided.