Chapter 6
Preparing a Food List for a Total Diet Study

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Introduction

The food list is an important part of a total diet study (TDS), as it contributes significantly to the precision and accuracy of the dietary exposure assessment for the chemicals examined. It is also the pivotal part reflecting many decisions taken in other parts of the TDS, such as objective of the study, data available, sampling, analysis of chemicals in the foods, representativeness of the results and the resources available to conduct the TDS.

Which Foods and How to Describe Them?

For a total diet study, the foods to be analyzed are 'foods as consumed', i.e. the edible part of the foods in the form they are eaten. Examples are cooked foods (e.g. grilled steak without bone; vegetable soup; boiled rice; steamed fish without bones, skin, or head), processed foods (e.g. cornflakes, bread, biscuits) or foods eaten raw but without the inedible part (e.g. banana without peel). Foods also include beverages (e.g. brewed coffee, black tea in liquid form, whole milk, beer, and wine) and drinking water. The latter is often forgotten because drinking water is usually not included in food consumption or supply data.

Accurate food descriptions are essential in order to clearly identify foods which are to be sampled and analyzed for the TDS and to assure that they are the same as

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those that were reported to be consumed by the population. In addition, foods may take different forms and have very different compositions, including contaminants. For example, 'tea' could be 'tea leaves', 'liquid tea', or 'tea powder' – and all would have different levels of contaminants. Therefore, it is important that a precise and clear food description be given for all individually analyzed foods as well as for those foods included as contributors to composite food samples.

When data from household budget surveys (HBS) or food supply/availability data (e.g. FAOSTAT or GEMS/Food Consumption Cluster Diets) are used to construct the a food list, they are reported raw agricultural commodiites (RAC) or 'as purchased', i.e. in the form they are bought (e.g. melon with skin, raw steak with bone, uncooked rice). Foods in such forms need to be transformed by appropriate edible coefficients and yield factors to foods 'as consumed' and the food descriptions of the TDS foods need to be adapted accordingly to avoid misinterpretation of results. The edible coefficient is the percent weight loss when discarding the inedible portion of a food. For example, a sample of 100 g of meat may contain 20 g of bones. Therefore, the edible coefficient would be 0.8. The yield factor indicates the percent weight change in foods or recipes due to cooking. For example, 100 g raw rice becomes 280 g boiled rice and the yield factor is 2.8; or when grilling beef, 30 % of its initial weight is lost and the yield factor is 0.7. More information on food description, nomenclature and food groups is found in the literature, such as Greenfield and Southgate (2003) [1] and Charrondiere et al. (2011) [2].

Before using food consumption survey data for TDS, they often have to be 'cleaned', i.e. implausible outliers need to be eliminated. Data deriving from 24-h-recalls often need to be aggregated, e.g. several brand names of the same food are grouped to avoid the possibility that important foods are not selected because they are split into too many smaller food records.

Construction of a Food List

The TDS food list is constructed in several steps. The first one is to select the most important foods in relation to exposure, the second to add special foods, the next step to consider other factors, and then lastly optimize the size of the TDS food list. The criteria used in the different steps are listed as follows:

Step 1. Identify most important foods in relation to exposure:

- Option 1: Select the foods or recipes consumed in largest amounts, e.g. >10 g/day then remaining foods consumed > 1 g/d [3];
- Option 2: Select the foods 'as consumed', arranged in descending order of consumption, contributing to a high percentage of the total diet by weight (ideally at least 90 % of the food intake) [4]; and
  Check that all key foods in the diet are included.

Step 2. Identify additional foods to be included for specific reasons:

- Add foods consumed by a significant proportion of the population, e.g. > 15 % of consumers;
- Add foods that may be consumed infrequently or in small amounts but are important in terms of potential contribution to dietary exposure, e.g. oysters or liver for heavy metals; or dried or powdered foods; or spices in certain diets; and
- Add foods important only for specific population groups or regions, e.g. infant formula, tofu, hummus

Step 3. Optimizing the food list:

- Organize all foods into foods groups;
- Eliminate foods NOT consumed by the population groups of interest;
- If the food consumption data is not very detailed, e.g. from HBSs, investigate the different forms that the food is consumed. For example, tomatoes – dried, canned or fresh; or chicken - fried, roast, stewed, tandoori;
- Check that all important foods are included potentially contributing to the exposure of the chemicals to be analyzed. For example, if only considering dithiocarbamates, the main priority foods should be fruits and vegetables, not oils or sweets;
- Decide which foods will be sampled as a regional or seasonal food (samples of the same food will be taken in different regions and/or seasons because it is believed that the concentration of the chemical may depend on the region and/or season) or as a national food (the food will be sampled at one site and season as the chemical concentration is supposedly similar throughout the year in the whole country); and
- Consider the available budget to decide which foods can be analyzed individually or as food group composites (i.e. several foods of the same food group are analyzed together), and for which chemicals. This would also consider the total number of foods on the list that will actually need to be purchased, transported, prepared and analyzed.

Ideally, foods included in the TDS should enable exposure assessments to be calculated for all important subgroups of the population, such as age/gender and ethnic groups taking regional or seasonal differences into account. To do so, however, all or most food samples would have to be analyzed separately. However, as this would require a very large budget, the process of constructing a food list will be a compromise between budgetary considerations and quality of exposure data which is in general highest when analyzing mostly individual foods. In other words, the goal is to have the least number of composites of different foods in order to obtain the optimal quality of the exposure assessments.

When conducting multi-national TDS, additional difficulties and decisions are involved and a harmonized methodology needs to be developed to assure data comparability. Concerning the food list, decisions will have to be taken, if foods would be country-specific or all in common or a mixture of common and country-specific foods. However, the same criteria and considerations apply as for a national TDS.

The determination of the final list of foods to be analyzed for a TDS depends therefore mainly on: (1) the objective of the TDS; (2) the availability of food consumption data; and (3) the budget available for the TDS.

Objectives of the TDS

The objective of the TDS determines the foods to be included and whether they will be analyzed separately or as a composite sample. If the objective of the study is to estimate heavy metal exposure, all foods potentially containing heavy metals should be included. If the objective is to estimate exposure to many contaminants, the food selection has to include all foods where they can be present, i.e. the entire food supply. Another example is the population to be covered; if different age and gender groups and/or regions should be covered, more foods should be analyzed individually (not as a composite of several foods) because the consumption of foods may differ significantly among these groups and regions. If the food consumption data permits only an exposure assessment per capita or per adult equivalent at a national level, a higher degree of compositing of different foods is possible.

Availability of Food Consumption Data

For every country, food consumption or supply data (See Chap. 4 – Overview of Dietary Exposure) are essential to build a reliable food list for a TDS. Ideally, every country should investigate the food consumption of its population on a regular basis for policy and planning purposes. However, this may not be done in many countries due to lack of resources. In the absence of such data, these countries should then start by using internationally compiled food supply data for their country such as published by FAOSTAT [5] (See Chap. 4 – Overview of Dietary Exposure) or the GEMS/Food Consumption Cluster Diets [6] (See Chap. 43 – GEMS/Food Consumption Cluster Diets) for their region.

Most countries would likely have some food consumption data, either on the household level or individual data. Household Budget Surveys (HBS) provide food consumption estimates per household of foods purchased or otherwise acquired (See Chap. 4 – Overview of Dietary Exposure). These data can be divided by the number of household members, if available, to obtain food consumption per adult equivalent (i.e. adjusted for age and sex requirements [7]) or per capita. In most cases, food consumption outside the household is not recorded, leading to an underestimation of food consumption. In some cases, only the amount of money spent for food purchase is available, which needs to be transformed into amounts of foods as purchased (through food prices at the time of the survey) and then into foods as consumed through edible coefficient and yield factor (See Fig. 6.1)

Individual food consumption surveys data are derived from food frequency questionnaires (FFQ), 24-h-recalls, food records, or dietary history. They are already expressed in foods as consumed per person per day, which means that no further

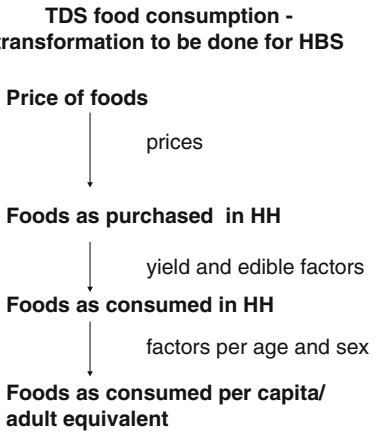

Fig. 6.1 Transformation of household budget survey (HBS) food consumption data to food as consumed per person or adult equivalent

Table 6.1 Food consumption/supply data provided from different sources

	Individual food consumption surveys	Household budget survey	GEMS/food; FAOSTAT
Data quality	High	Intermediate	Low
Availability	Exist in few countries and researchers normally are reluctant to release data, except published summary data	Exist in many countries, e.g. from statistical office	Can be downloaded from the FAO and WHO Internet sites
Resources needed to carry out a survey	High	Medium	Already available on web
Data provided	Edible foods as consumed	Foods as purchased	Raw commodities (food supply data)
Disaggregation	Age, sex, bodyweight, socio-economic status, ethnicity, region, etc.	None	None
Data needed to transform	None	Sometimes prices Edible portion Yield factor Adult equivalent (AE) factors	Edible portion Yield factor
Results	Individual consumption of edible foods as consumed	Consumption of edible foods as consumed per AE	Consumption of edible foods as consumed per capita

transformation is necessary to build the TDS food list. These data, if available from a national survey, are of the best quality and should be used as a first priority. Summary information of the different food consumption/supply data is shown in Table 6.1 and more detailed information on these data and surveys is available [8].

It is appropriate to include foods and recipes in the TDS as most people do not always eat single foods, but eat them in the form of mixed dishes. Recipes can be

prepared at home or bought as such (e.g. hamburgers, restaurant meals). FFQs and 24-h-recalls normally report foods and recipes and the most common dishes could be included in the TDS. However, food supply or HBS data do not include recipes and if these data are used, it is therefore necessary to investigate how the foods to be included in the TDS food list are prepared by the population. This information can be obtained from cook books, focus group discussions, published literature, or other reports. Foods are normally prepared in a number of different ways (e.g. potatoes are boiled with or without skin, fried, mashed, deep fried as fries and chips or are roasted). Each of these may have a different contamination level, as in the case of acrylamide. The TDS investigator has therefore to decide which forms of the different foods will be included in the TDS. The options include: (1) all reported preparation methods, (2) only the single most prevalent one, or (3) the most important ones. Some select only one preparation per food, while others choose the most important ones, especially if the preparation method is known to change the contamination level.

If recipes are analyzed, it will be difficult to determine the food(s) containing the contamination. Therefore, some TDS only analyze foods and no recipes, meaning that they will add the amount of each recipe ingredients to the corresponding foods.

Sometimes, food consumption surveys do not cover the whole year and therefore, seasonal foods might not be reported or in too small amounts. Additional investigations may be necessary in this case and result in an increase in some amounts consumed.

In many countries, certain foods are fortified and some people consume vitamin and mineral supplements. Therefore, care should be taken to include these data, if available, in the study design of TDS, especially if minerals and other nutrients are to be analyzed. If this was not done, the nutrient intake could be grossly underestimated.

Data from HBS and individual consumption surveys allow the construction of a distribution curve, which is useful for more sophisticated exposure assessments. It is often necessary to purchase food consumption data from institutes or statistical departments. In these cases, the TDS convener has to communicate to the data owner which data should be extracted from the database for the population groups of interested and if possible, separated by age, gender, region and for consumers only, e.g. mean and/or median food consumption and to represent high consumers also the high percentiles, preferably 97.5th.

Budget

The bigger the budget allocation for the TDS, the more foods can be analyzed individually and the more foods per region and seasons can be investigated. TDSs usually have limited funds available and therefore have to include greater numbers of composites of different foods and/or lower numbers of chemicals to be analyzed. If the budget is insufficient, the objective of the TDS needs to be adapted accordingly, e.g. more composites of different foods and/or fewer analytes, food samples, regions, brands and/or seasons. The advantages and disadvantages of compositing samples,

and individual food versus food group composites are discussed in Chap. 9 – Food Sampling and Preparation in a Total Diet Study. It is, however, unwise to compromise on the analytical quality because low quality analytical data will jeopardize the whole TDS (See Chap. 13 – Quality Control and Assurance Issues Relating to Sampling and Analysis in a Total Diet Study). The quality of the TDS also depends on the dilution effect i.e. when compositing many foods of different concentration levels the final concentration may be under the limit of detection or quantification and the overall exposure to the chemical could significantly be underestimated.

If a broad exposure assessment to many contaminants is the main purpose of the TDS and only a limited budget is available, it will be necessary to have a greater number of composite samples for the different foods. If regional differences in exposure to one group of hazards (e.g. heavy metals) is the main objective, then more regional food samples need to be collected, but more foods may have to be composited into one sample to keep the number of analyzed foods reasonable.

It takes about 5 years (probably less for a HBS) to plan, implement and analyze a food consumption survey on individuals and significant of resources (budget and technical expertise) are required. It is therefore often better to access existing or purchase available food consumption data than to carry out a food consumption survey, even if not all of the desired data were available.

Compositing of Food Samples

The purpose of compositing foods is to retain their contribution to exposure while saving funds on the cost of analysis because fewer samples need to be analyzed. The disadvantage of compositing is that: (1) it is not possible to know the contamination of each food; (2) the dilution of the contamination of one food in the composited sample; and (3) the amounts of each contributing food in the composite are fixed for the age-gender group being considered and cannot be adapted to different consumption amounts of different population groups or regions. Compositing of foods, as mentioned earlier, is mainly guided by financial considerations. In order to obtain good analytical data for the exposure assessment, the choice of compositing could be guided by the following principles:

1. Highly consumed foods should be analyzed separately.
2. Foods with known or potentially high contamination levels should be analyzed separately for the specific contaminant.
3. Less frequently consumed foods of the same food group can be composited
4. Foods of the same food group with expected low and similar contamination can be composited.
5. Compositing of foods can be done differently for different contaminants as long as all foods are included in a composite or analyzed individually for this contaminant.
6. Compositing of foods from different regions or seasons to one national food is reasonable if the contamination is known, or thought, to be equally distributed.

7. When very limited funds are available, compositing of foods is the only means of obtaining a rough estimation of exposure, e.g. some TDSs have one composite per food group.
8. Many first-time TDS have a higher percentage of compositing because of limited funding. With time and recognition of the usefulness of the results, funding may increase and therefore the percentage of compositing may decrease.

Examples

Composite of a single food:

- 15 apples of different varieties as consumed in the population
- For 'yogurt' a mix of different yogurts: plain yogurt, with flavor, with fruits, of whole milk or skimmed milk according to the consumption pattern in the population
- Biscuits: five main brands

Composite of different foods:

- Fruits infrequently consumed, e.g. in a European country, mix of mangoes, papayas, starfruits, and lychees.
- All fruits consumed.
- Millet and sorghum composite: Mix of 40 % raw white millet + 40 % raw yellow millet + 10 % raw sorghum. The mix is then prepared in two ways: boiled couscous and porridge. Final composite consists of 50 % prepared couscous + 50 % porridge.

Practical Considerations When Constructing a Food List

The following steps could be performed (See also Fig. 6.1):

1. 'Clean' the food consumption data (e.g. disregard implausible outliers).
2. Select for each food the appropriate preparation method (as prepared by the majority of the population).
3. Select and apply appropriate edible coefficients and yield factors (to calculate food consumption for foods as consumed).
4. In a spreadsheet, such as Excel, sort the food consumption data for the entire population in descending order (most consumed foods on top of the list), add cumulative consumption in g/d and in %.
5. In a spreadsheet, such as Excel, sort the food consumption data for consumers only, if these data are available, in descending order (most consumed foods on top of the list), add cumulative consumption in g/d and in %.
6. Select foods for the TDS according to your main criteria (see criteria above).
7. Add foods not selected with the main criteria (see criteria above).
8. Put the foods into food groups.

9. Optimize the food list and decide on compositing of foods within a food group (see criteria above).
10. Decide on chemicals to be analyzed in each composited food sample.
11. Calculate costs for sampling, transportation and analysis of foods and of other costs.
12. Compare costs with available budget.
13. Adjust the number of foods and composited foods as required.

Useful Resources

Examples of food lists are found in the publications of national TDS reports or in the corresponding scientific articles. The following resources provide useful guides to food nomenclature and yield factors and edible coefficients, as well as on the new EFSA/FAO/WHO guidance document on TDS [4] and the accompanying document describing selected TDS studies [3].

Food Nomenclature

LANGUAL – The International Framework for Food Description. Available at http://www.langual.org

INFOODS – Food Nomenclature. Available at http://www.fao.org/infoods/infoods/standards-guidelines/food-nomenclature/en/

Langual Food Description Thesaurus and the Food Product Indexer. Available at http://www.langual.org/langual_food_product_indexer_database_2012.asp

Yield Factors and Edible Coefficients (see http://toolbox.foodcomp.info/ToolBox_RecipeCalculation.asp)

Bell et al. 2006. *Report on Nutrient Losses and Gains Factors Used in European Food Composition Databases* (D1.5.5).

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