



## Methodology design of the regional Sub-Saharan Africa Total Diet Study in Benin, Cameroon, Mali and Nigeria



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### ABSTRACT

The core food model was described more than three decades ago, and has been used ever since to identify main food contributors to dietary intakes for both nutrients and other food chemicals. The Sub-Saharan Africa Total Diet Study (SSA-TDS) uses this model to describe the food consumption habits of some selected populations of Benin, Cameroon, Mali, and Nigeria, prior to use in the completion of quantitative risk assessments with regard to food chemicals. Food consumption data were derived from food expenditure data contained in national household budget surveys that were provided by the national institutes of statistics in each country. A classification of African foods was established for the purpose of the study and core foods were selected, so as to reflect  $96 \pm 1\%$  of the average national total diet expressed in weight. Populations from eight study centers were selected by national stakeholders. This approach involves the purchase of 4020 individual foods, prepared as consumed and pooled into 335 food composite samples, for analysis of mycotoxins, PAHs, PCBs and dioxins, pesticides, metals and trace elements, PFAs, and BFRs. This sampling plan aims to provide a representative, cost effective, and replicable approach for deterministic dietary exposure assessments in developing countries.

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### 1. Introduction

Evaluating the human exposure to potentially harmful substances is a key step in public health risk assessments. A better understanding of these exposures leads to evidence-based decision-making processes, providing for improved risk management at national and international levels.

The dietary exposure of a given population to food chemicals

can be assessed by different approaches (FAO/WHO, 1985; WHO, 2009). The most refined approach for obtaining food chemical concentration data to be used in dietary exposure assessments involves purchasing the foods people eat and analysing these foods. Assessing the occurrence of chemicals of interest in foods as consumed in order to effectively estimate the dietary exposure for different population groups requires an efficient, cost-effective, and accurate method, such as Total Diet Studies (TDS). The TDS approach has been promoted and endorsed by the World Health Organization (WHO) along with the Food and Agriculture Organization of the United Nations (FAO) since the 1960s (WHO, 1968) and more recently in 2011 in a joint guidance document from European Food Safety Authority (EFSA), WHO and FAO (EFSA, 2011b).

TDS are designed to measure the average amount of a given substance ingested by a studied population. This public health oriented approach differs from classical chemical surveillance programs because: (1) it focuses on chemicals in the total diet rather than in specifically targeted food commodities and (2) it takes into consideration, to a certain extent, the impact of home cooking on the decomposition or formation of chemicals, as the foods are prepared as for consumption before analyses (WHO, 2007).

The core food approach was first described in 1982 for the US Total Diet Study (Pennington, 1983; Egan et al., 2007) and has since been used as a common tool by other food safety agencies around the World (EFSA, 2011a; WHO, 2009). A TDS enables identification of foods that are most highly consumed by a study population (in terms of quantity) and which foods contribute most to intakes of energy, nutrients, and other food chemicals. A core food list gathers the main foods representing at least 90% by weight of the average total diet. These foods are sampled and analyzed for the assessment of nutritional intakes or dietary exposure to other food chemicals of a given population.

Two specific aspects characterize a TDS: (1) the representativeness of the sampling and (2) the preparation of the samples “as consumed”, so that it represents a pertinent public health risk assessment tool, as far as food safety and nutrition are concerned.

The four key steps of a TDS implementation within a specific population include (1) the identification of core foods (2) the derivation of both the average and the high-consumers daily food consumption (3) the sampling, preparation (i.e. prepared and cooked as per the typical consumer behavior), and laboratory analyses of the sampled core foods for nutrients and/or other food chemicals and (4) the exposure assessment and risk characterization obtained from consumption data multiplied by food chemicals concentration data.

Between 2006 and 2010, a TDS was implemented in the city of Yaoundé, Cameroon for the purpose of screening pesticides (Gimou et al., 2008) and metals and trace elements (Gimou et al., 2014). This first ever TDS implemented in Sub-Saharan Africa used a food list including 63 food items obtained from the pooling of national food items from the Cameroonian Household Budget Survey. The Sub-Saharan Africa Total Diet Study (SSA-TDS) is a wider project aiming to investigate a more extended number of food chemicals, within a larger study population.

The SSA-TDS was implemented by FAO in Benin, Cameroon, Mali and Nigeria between 2014 and 2017, together with the four national food safety authorities, in close collaboration with Center Pasteur of Cameroon (CPC) and WHO (FAO, 2014a).

Due to budget constraints, the national stakeholders of the four countries decided to select only two population groups per country. The basis for the selection of the two different population groups per country was distinct dietary behaviors, associated with distinct agro-ecological areas. These study centers include in each country (1) the most densely populated city (Bamako, Cotonou, Duala and

Lagos), among which three are located by the Atlantic Ocean Coast, and (2) another study center located in a non-coastal area (the Sikasso Region of Mali, the Borgou Department of Benin, the North Region of Cameroon and the State of Kano of Nigeria).

The design and main methodological choices, forming the basis of the Sub-Saharan Africa Total Diet Study (SSA-TDS) in terms of selection of core foods, food sampling approach, food sample preparation and chemical substances looked for, which represent the main challenges for implementing and adapting the TDS approach for developing countries, are presented here below.

## 2. Materials and methods

### 2.1. Food classification and food consumption data

Food consumption data were derived from household budget surveys (HBS) available in Benin, Cameroon, Mali, and Nigeria. The four HBS gather data from a total of 72,979 households and include both the estimated value of food produced by households for their own consumption and the amount spent for each food commodity recorded by national institutes of statistics and expressed in local currency and recorded over a two-week period.

Data recorded by the four national institutes of statistics used heterogeneous food nomenclature, including the total number of distinct food items recorded ranging from 163 (Mali) to 284 (Cameroon). In order to generate comparable food consumption data among the 4 countries, two additional and harmonized levels were added to the food classification as shown in Fig. 1.

The adopted strategy consisted of setting up a corresponding table for each country between the national food items representing 100% of the average national diet and two additional levels that are of a higher ranking. The two additional levels are (1) 84 food subgroups, among which core foods are selected for the purpose of the study and considered to be the maximum pooling level for sampling and (2) 13 food groups taken from the food classification used in the West African Food Composition Table (FAO, 2012). These corresponding tables were filled for each country starting with the lowest ranking level (i.e. for each national food item table), entering edible fraction conversion factors, yield factor (reflecting weight change during the cooking process) and energy content either obtained from the West African Food Composition Table (FAO, 2012) or the French Food Composition Table (ANSES, 2013).

In order to obtain a standardized unit to describe the energy intake of the study population, the sex and age of every household member was systematically recorded in each of the four national household budget surveys (HBS), and converted into adult male equivalents (AME) using the equivalence scale from Nigeria (Table 1).

The relevance of using AME for estimating household energy requirement was summarized by the United Nations University (Weissell and Dop, 2012). Estimating the energy requirement of a household serves to select households whose declared food expenditure corresponds to a realistic range of energy intake.

Food consumption data were estimated as daily consumption of food “as consumed” in grams per adult male equivalent per day derived using the following three-step process: (1) food expenditure and food produced by households for their own consumption reported by national HBS in local currency recorded over a two-week period and converted into “daily quantity of raw food commodity purchased” with the help of a unit price database provided by each national institute of statistics (2) quantities of raw food commodity purchased or produced for household consumption converted into “daily quantity of edible raw food commodity” with edible fraction conversion factors identified in the West African

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