intake
CENTER FOR DIETARY ASSESSMENT

SURVEY GUIDANCE DOCUMENT

How to Compile a Portion Size Estimation Method Conversion Factor Database for a Quantitative 24-Hour Dietary Recall Survey

Authors: Marieke Vossenaar, Christine Hotz, Joanne Arsenault, Megan Deitchler, Mourad Moursi, Abdelrahman Lubowa, and Mary Arimond

December 2022

Recommended Citation

Vossenaar M, Hotz C, Arsenault J, Deitchler M, Moursi M, Lubowa A, and Arimond M. 2022. *How to Compile a Portion Size Estimation Method Conversion Factor Database for a Quantitative 24-Hour Dietary Recall Survey.* Washington, DC: *Intake* – Center for Dietary Assessment/FHI Solutions.

About *Intake*

Intake is a Center for Dietary Assessment that aims to strengthen policies and programs to improve nutritional status by increasing the availability, quality, comparability, and use of reliable dietary data in low- and middle-income countries (LMICs). We hope that the availability of valid, concise, effective diet-related metrics, along with *Intake* technical assistance for the planning, design, collection, analysis, and use of dietary data, can play an important role in helping actors in LMICs to develop evidence-based nutrition and agriculture policies and programs to ensure high-quality diets for all.

User Feedback

At *Intake*, we aim to make our technical assistance tools, templates, and guidance materials as useful as possible. We therefore welcome input and feedback from users of our technical assistance documents, so that we can continue to improve the materials and the technical assistance we provide. If you have suggestions or feedback related to this document that you would like to share with *Intake*, please contact us via email at feedback@intake.org.

Contact Information

Intake – Center for Dietary Assessment
FHI Solutions
1825 Connecticut Avenue, NW
Washington, DC 20009–5721

Intake.org

Contents

List of Tables

List of Figures

List of Boxes

List of Abbreviations

2D	two-dimensional
3D	three-dimensional
CV	coefficient of variation
FRIL	food, recipe, and ingredient listing
g	gram(s)
kg	kilogram(s)
ml	milliliter(s)
LMICs	low- and middle-income countries
NA	not applicable
PSEM	portion size estimation method
SD	standard deviation

Definitions and Usage of Terms

Edible portion: The parts of a food that are typically consumed after all inedible parts are removed, if the food has any. For example, the part of the avocado left after the peel and pit have been removed.

Edible portion factor: A numeric value needed during data processing to account for any inedible parts of a food (e.g., bones, seeds, pits, peels). During data processing, the edible portion factor is used to convert the amount of food reported as consumed into its equivalent edible weight in grams (i.e., "grams consumed" or "grams of ingredient used"). The edible portion factor is calculated as the ratio of the edible portion of a food to the entire food (i.e., the edible portion factor = edible portion ÷ [the edible portion + inedible portion]). The edible portion factor is a value between 0 and 1; it is equal to 1 when the entire food is edible (i.e., there are no inedible parts). Each food in the food, recipe, and ingredient listing (FRIL) should have an associated edible portion factor listed in the portion size estimation method (PSEM) conversion factor database.

Food: A food that is not mixed with other foods (e.g., banana, groundnuts). For simplicity in language, in this document, we use the term "food" broadly to also refer to beverages. Composite foods, such as bread and cakes, which are prepared with multiple ingredients but are often included in a food composition table as a single food item may also be treated as a single food in the FRIL for the purpose of dietary data collection.

Food density: Mass per unit volume (e.g., gram/ml). Used in dietary assessment to convert the weight of a proxy material (such as playdough, raw rice, Kinetic Sand®) and the pre-determined volume of a calibrated household utensil into the estimated amount (in grams) of food or mixed dish consumed.

Food item: A term used to refer collectively to foods, beverages, and mixed dishes consumed, as well as to the ingredients used to prepare a mixed dish.

Food, recipe, and ingredient listing (FRIL): A comprehensive list of all foods, beverages, recipes, and ingredients—and their relevant descriptive details—that are likely to be encountered during the 24-hour dietary recall interviews carried out across all geographic areas where the survey will be implemented and for all demographic groups that will be included in the survey. The FRIL should list each food, recipe, and ingredient in the state (e.g., raw, boiled, steamed, grilled, fried), form (e.g., whole, sliced, diced, mashed, pureed), and presentation mode (e.g., served with or without inedible parts) in which it is consumed (or used in a mixed dish).

Group I PSEMs: PSEMs well suited for use in large-scale dietary surveys in low- and middle-income countries (LMICs) because they do not require extensive preparatory work in advance of data collection for the development of the necessary tools and aids. These PSEMs include direct weight using food replicas; standard unit size; proxy weight using a material that can be shaped, such as playdough; proxy weight using a free-flowing material, such as raw rice; proxy weight using a material that heaps, such as Kinetic Sand®; and calibrated household utensils, such as spoons, scoops, and ladles.

Group II PSEMs: PSEMs that are suitable for use in large-scale dietary surveys in some low- and middle-income settings, but whose use may be limited because they typically require extensive preparatory work in advance of data collection for the development of the necessary tools and aids. These PSEMs include graduated portion-size food photographs, full-size food photographs, two-dimensional (2D) shapes, and three-dimensional (3D) food models.

Homogenous mixed dish: A mixed dish in which all ingredients are more or less evenly distributed. Any serving from a mixed dish contains similar proportions of the constituent ingredients.

Inedible portion (also called "inedible part" or "'non-edible part"): The parts of a food that are typically included in the food when served but not consumed. Examples of foods that are commonly served with inedible parts include

chicken, fish, and other meat served with bone; groundnuts in the shell; maize on the cob; and fruits with inedible seeds, pits, or peels.

Ingredient: A food that is used in a mixed dish.

Ingredient proportion (in a recipe): Refers to the proportion of a prepared mixed dish that is composed of a given ingredient. For example, if the weight of an ingredient used to prepare a mixed dish is 60 g and the total weight of the prepared mixed dish is 200 g, the ingredient proportion for that ingredient is 0.30 (60 / 200).

Ingredient proportion "gram to gram ratio": An ingredient proportion in which both the amount of the ingredient used in a mixed dish and the total amount of the prepared mixed dish are weighed and expressed in grams of food. A "gram to gram ratio" is used in recipe calculations for standard recipes and non-standard recipes when different PSEMs are used to estimate the amount of mixed dish prepared and the amount of mixed dish consumed by the respondent.

Ingredient proportion "gram to PSEM ratio": An ingredient proportion in which the amount of the ingredient used in a mixed dish is expressed in grams of food, but the total amount of the prepared mixed dish is expressed in grams of a proxy material used as a PSEM for estimating the amount of mixed dish prepared (e.g., raw rice). A "gram to PSEM ratio" is used in recipe calculations for non-standard recipes when the same PSEM is used to estimate the amount of mixed dish prepared and the amount of mixed dish consumed by the respondent

Mixed dish: A dish, usually with a specific culinary name, that is prepared using two or more ingredients. Exceptions are usually made for food items where the second ingredient is a flavoring (e.g., salted nuts, fruit with sugar). Fried foods, such as fried potatoes, are typically considered a single food item even though they constitute a mixture of two different foods (i.e., oil and potatoes). Long-established composite foods such as bread and cakes, which are prepared with multiple ingredients, are often also treated as a single food item. Composite baked goods such as these can be found in the food composition tables of many different countries.

Non-homogenous mixed dish: A mixed dish in which ingredients are not evenly distributed. Any serving from a mixed dish does not necessarily contain similar proportions of the constituent ingredients. Typically, non-homogenous mixed dishes refer to dishes in which the ingredients that are not evenly distributed in the mixture are nutrient-dense (e.g., chunks of red meat, fish, or poultry in a stew).

Non-standard recipe (also called a "household recipe" or "unique recipe"): A recipe derived from data collected in a household during a 24-hour dietary recall interview. During the interview, the respondent, or the cook of the mixed dish, provides the details of the mixed dish consumed by the respondent; these include a detailed description of the ingredients and the amounts used, the total amount of the mixed dish prepared, and the amount of the mixed dish consumed.

Portion size estimation method (PSEM): A method used to estimate the amount of food, beverage, or mixed dish consumed by survey respondents; the amount of an ingredient used; or the total amount of a mixed dish prepared. As there is no single PSEM that can be used for all food items likely to be encountered in a survey, a set of different PSEMs must be selected for use in a survey. The use of PSEMs in dietary surveys in LMICs often requires the use of equipment, tools, and aids, such as dietary scales, proxy materials (e.g., playdough, raw rice, Kinetic Sand®), household utensils, food photographs, 2D shapes, and 3D food models.

Proxy material density: Mass per unit volume (e.g., gram/ml). The density of proxy materials (such as playdough, raw rice, Kinetic Sand®) is used in dietary assessment to convert the weight of a proxy material into the estimated amount (in grams) of food or mixed dish consumed.

PSEM conversion factor: A numeric value needed during data processing to convert the amount of a food item reported as consumed using a pre-determined PSEM into its equivalent edible weight in grams (e.g., "grams consumed," "grams of ingredient used," "grams of recipe prepared") after accounting for any inedible parts of that food (e.g., bones, seeds, pits, peels). The PSEM conversion factor for a given food

item is calculated by multiplying the "PSEM-specific factor" by the "edible portion factor." Every food item in the FRIL should have an associated PSEM conversion factor listed in the PSEM conversion factor database, for each PSEM assigned to that food item.

PSEM conversion factor database: A survey-specific database that details the PSEM conversion factors needed to convert the amounts of food items reported as consumed, which have been estimated using pre-determined PSEMs, into their equivalent weight in grams, after accounting for any inedible parts of those foods (e.g., bones, seeds, pits, peels). A PSEM conversion factor is needed for each food item included in the FRIL, for each PSEM assigned to that food item.

PSEM-specific factor: A numeric value needed to convert the amount of a food item reported as consumed, estimated using a pre-determined PSEM, into its equivalent weight in grams (e.g., "grams consumed," "grams of ingredient used," "grams of recipe prepared") before accounting for any inedible parts of that food (e.g., bones, seeds, pits, peels). Every food item in the FRIL should have an associated PSEM-specific factor listed in the PSEM conversion factor database, for each PSEM assigned to that food item.

Recipe: A description of a mixed dish that provides the list of ingredients used to prepare the mixed dish, along with a detailed description of all ingredients used (including any processing and cooking methods applied to each ingredient before adding the ingredient to the mixed dish). The cooking methods applied to the mixed dish itself (if the dish is cooked) are also included as part of the recipe information. In dietary surveys, a recipe includes information on the quantity (in grams) of each ingredient used to prepare the mixed dish (in the form added to the mixed dish, which is typically raw) and the final quantity of the mixed dish once it is fully prepared (e.g., cooked).

Remaining mixture: The component of a non-homogenous mixed dish that remains after nutrient-dense ingredients (e.g., chunks of red meat, fish, or poultry in a stew) are removed (e.g., the remaining broth, sauce, rice mixture).

Standard recipe: An "average" recipe that aims to reflect the way that a mixed dish is usually prepared by respondents in a survey area. Standard recipes can be used for mixed dishes that are known to be prepared similarly across a defined survey area (in terms of the ingredients used, the relative proportion of each ingredient used in the mixed dish, and the preparation methods for those ingredients and for the mixed dish itself). Standard recipes are also typically used when survey respondents report consuming mixed dishes prepared outside the home (e.g., by vendors, in restaurants).

Substitution factor: An additional conversion factor (i.e., numeric value) that is required during data processing to translate the portion size reported as consumed, as depicted in a graduated portion-size food photograph or by a food replica when using direct weight as the PSEM, into the portion size of the substitution food item consumed.

Substitutions: Refers to using a PSEM developed for use with a specific food item to estimate the portion size consumed for a set of similar food items that are not represented or depicted (e.g., use of graduated portion-size food photographs depicting cooked spinach to assess the amount of cooked kale consumed). Survey planners can consider the use of substitutions when using direct weight and graduated portion-size food photographs as PSEMs.

1 Introduction

During a quantitative 24-hour dietary recall interview, various portion size estimation methods (PSEMs) are used to aid a respondent in estimating the amount of each food item reported as consumed.[1] Extensive guidance on the selection and use of PSEMs in 24-hour dietary recall surveys in low- and middle-income countries (LMICs) is available elsewhere.[2] In short, the appropriate PSEM to use for a given food item depends on its state, form, and presentation mode, as well as contextual factors related to the survey. These include the time and resources available to devote to the development of tools and aids required for the PSEMs and the numeracy level of both the target population for the survey and the enumerators collecting the dietary data.

Common PSEMs used in large-scale quantitative dietary surveys are described briefly in Table 1. For ease of reference, we categorize these PSEMs into two groups, depending on the amount of time and resources required for the development of the tools and aids required for their use in a survey. Group I PSEMs—direct weight using food replicas, standard unit size, proxy weight using a material that can be shaped (e.g., playdough), proxy weight using a free-flowing material that is pourable (e.g., raw rice), proxy weight using a material that heaps (e.g., Kinetic Sand®[3]), and calibrated household utensils (e.g., spoons, scoops, ladles)—do not typically require extensive preparatory work for their use, whereas Group II PSEMs—graduated portion-size food photographs, full-size food photographs, two-dimensional (2D) shapes, and three-dimensional (3D) food models—often require many months to prepare the tools and aids needed during data collection.

Across the set of PSEMs, portion size information is collected in different units (e.g., grams of food replica, grams per standard unit, grams of proxy material, volume of the selected utensil, grams of size depicted). However, for analysis of the dietary data collected, the portion size data collected must be converted into the gram weight of the edible portion of the food item consumed. To translate the quantity of consumption information collected during the 24-hour dietary recall into grams of edible food items consumed, a PSEM conversion factor must be applied to each food item reported as consumed. The conversion factor required will vary by food item and by assigned PSEM and according to whether an inedible portion was included when the respondent estimated the amount consumed.

To facilitate the conversion of consumption information collected during the 24-hour dietary recall interview into grams of edible food items consumed, a survey-specific PSEM conversion factor database is required. The purpose of the PSEM conversion factor database is to provide all necessary details related to the PSEM conversion factors that will be required during data processing to convert the amounts of each food item reported into a gram unit weight of the edible portion consumed. This database should be compiled after the assignment of PSEMs to the food items in the food, recipe, and ingredient listing (FRIL) developed as part of pre-survey activities,[4] and ideally before data collection for the survey begins.

The work to compile a PSEM conversion factor database can be complex and time-consuming. The purpose of this guidance document is to outline the necessary steps and provide technical guidance for the compilation of a PSEM conversion factor database for a dietary survey. In this document, we provide guidance on how to construct and calculate PSEM conversion factors for each Group I and Group II PSEM (Section 2); describe the

[1] For simplicity, we refer to food items consumed, but several PSEMs can also be used to estimate amount of an ingredient used and the total amount of a mixed dish prepared. Also, for simplicity, in this document the term "food item" refers collectively to foods, beverages, and mixed dishes consumed, as well as to ingredients used to prepare a mixed dish.

[2] For detailed guidance related to PSEMs, see Vossenaar M, Lubowa A, Hotz C, Deitchler M, Moursi M, Arimond M, Crispim SP, and Arsenault J. 2020. *Considerations for the Selection of Portion Size Estimation Methods for Use in Quantitative 24-Hour Dietary Recall Surveys in Low- and Middle-Income Countries.* Washington, DC: *Intake* – Center for Dietary Assessment/FHI Solutions. Available at: Intake.org.

[3] Kinetic Sand® is a non-toxic commercial product made with sand and polymers. It mimics the physical properties of wet sand; it has a loose texture, is flexible, does not stick on hands, and does not dry out.

[4] For further guidance on pre-survey activities, such as the development of the FRIL, see Vossenaar M, Arimond M, Deitchler M, Lubowa A, Hotz C, and Moursi M. 2020. *An Overview of the Main Pre-Survey Tasks Required for Large-Scale Quantitative 24-Hour Recall Dietary Surveys in Low- and Middle-Income Countries*. Washington, DC: *Intake* – Center for Dietary Assessment/FHI Solutions. Available at: Intake.org.

specific considerations related to the use, construction, and calculation of PSEM conversion factors for mixed dishes (Section 3); provide guidance for collecting and compiling the data required to develop a complete database of PSEM conversion factors for a given survey (Section 4); and describe the format of a PSEM conversion factor database (Section 5).

Table 1. PSEMs for Use in Large-Scale Quantitative 24-Hour Dietary Recall Surveys in LMICs[A]

PSEM	Equipment, tools, and aids required[B]	Use of PSEM during the 24-hour dietary recall		Measurement unit in which the portion size data are collected
		Steps to be undertaken by the respondent[C]	Steps to be undertaken and recorded by the enumerator[D]	
Group I PSEMs: Methods that do not require extensive preparatory work in advance of the survey				
1. **Direct weight** using food replicas[E]	Food replicas High-quality digital dietary scales (along with high-quality batteries and certified standard weights for scale testing). Commonly used plates and bowls Utensils to scoop the replica Storage containers	The food replica of the actual food consumed is placed on a plate or in a bowl to represent the amount consumed. Ideally, the same plate or bowl used by the respondent is used when estimating the portion size consumed. Depending on survey operationalization, substitutions may be allowed.[F]	The food replica that represents the amount consumed is weighed on a digital dietary scale and the weight is recorded to the nearest gram. If relevant, substitutions are recorded.	Grams of food replica
2. **Standard unit size** (each unit corresponds to a known weight)	None[G]	A food item that occurs in uniform size units is reported. The number (multiples) and/or fractions consumed of the selected unit are reported.	The code of the selected standard unit size is recorded. The number and/or fractions of units reported is recorded.	Grams per standard unit

[A] This table is adapted from Table 1 in Vossenaar M, Lubowa A, Hotz C, Deitchler M, Moursi M, Arimond M, Crispim SP, and Arsenault J. 2020. *Considerations for the Selection of Portion Size Estimation Methods for Use in Quantitative 24-Hour Dietary Recall Surveys in Low- and Middle-Income Countries.* Washington, DC: *Intake* – Center for Dietary Assessment/FHI Solutions. Available at Intake.org.

[B] In addition to the equipment, tools, and aids listed in this table, a PSEM list should be developed by survey planners to specify the PSEMs assigned to each item in the FRIL to guide the enumerator during the 24-hour dietary recall interview.

[C] For simplicity, we refer to food items consumed, but several PSEMs can also be used to estimate the amount of an ingredient used and the total amount of a mixed dish prepared.

[D] For food items for which amounts consumed can be estimated with the inedible portions included (e.g., chicken, fish, and other meat served with bone), the enumerator must always record if inedible parts were included or not when estimating the amount consumed.

[E] Salting can be used to preserve foods that spoil quickly, but some foods do not require salting to be preserved and, for other foods, salt should not be used, as this can cause the consistency of the food to change (e.g., sweet potatoes).

[F] Whether and for what foods the use of substitutions is allowed depends on the survey context; these decisions must be made before data collection.

[G] Alternatively, photographs can be used to confirm that the food item reported is the same as the one for which the PSEM was developed. This verification should be done during the "second pass" of the 24-hour dietary recall when descriptive details for the food item are collected (e.g., brand of commercial food).

PSEM	Equipment, tools, and aids required[B]	Use of PSEM during the 24-hour dietary recall		Measurement unit in which the portion size data are collected
		Steps to be undertaken by the respondent[C]	Steps to be undertaken and recorded by the enumerator[D]	
3. **Proxy weight using a material that can be shaped** (e.g., playdough)[H]	Playdough (or other suitable proxy material) High-quality digital dietary scales (along with high-quality batteries and certified standard weights for scale testing) Commonly used plates, bowls, and pots Storage containers	A piece of playdough is modeled into the size and shape of the food item consumed to represent the amount consumed, and is placed on a plate or in a bowl or pot. Ideally, the same plate, bowl, or pot used by the respondent is used when estimating the portion size consumed. If relevant, multiples of uniform unit sizes molded are reported.	The playdough is weighed on a digital dietary scale and the weight is recorded to the nearest gram. If relevant, the number of uniform unit sizes reported is recorded.	Grams of proxy material
4. **Proxy weight using a free-flowing material that is pourable**[I] (e.g., raw rice)[J]	Raw rice (or other suitable proxy material) High-quality digital dietary scales (along with high-quality batteries and certified standard weights for scale testing) Commonly used cups, bowls, and pots Utensils to scoop the raw rice Storage containers	The raw rice is poured into a cup, bowl, or pot to represent the amount consumed. Ideally, the same cup, bowl, or pot used by the respondent is used when estimating the portion size consumed. If relevant, multiples of uniform unit sizes poured are reported.	The raw rice is weighed on a digital dietary scale and the weight is recorded to the nearest gram. If relevant, the number of uniform unit sizes reported is recorded.	Grams of proxy material

[B] In addition to the equipment, tools, and aids listed in this table, a PSEM list should be developed by survey planners to specify the PSEMs assigned to each item in the FRIL to guide the enumerator during the 24-hour dietary recall interview.

[C] For simplicity, we refer to food items consumed, but several PSEMs can also be used to estimate the amount of an ingredient used and the total amount of a mixed dish prepared.

[D] For food items for which amounts consumed can be estimated with the inedible portions included (e.g., chicken, fish, and other meat served with bone), the enumerator must always record if inedible parts were included or not when estimating the amount consumed.

[H] High-quality playdough is the most suitable proxy material to use for this PSEM because it is easy to mold and has been used extensively in different settings without major challenges.

[I] This PSEM is similar to "volume by proxy material" in which the respondent uses a proxy material (e.g., raw rice) to represent the amount of the food item consumed and the volume is measured. The difference is that *Intake* recommends weighing the amount of proxy material using a dietary scale (and recording the weight in grams) instead of using a cylinder to measure the volume of the proxy material (and recording the volume in ml) because taking the weight measurement of the proxy material is easier, faster, and less prone to error than taking a measure of the volume of the proxy material.

[J] Raw rice is the most suitable proxy material to use for this PSEM because it is easy to handle, readily available, safe to use, and retains a constant density when stored and handled properly. The use of water for this PSEM is discouraged because it is cumbersome to carry, and, in many settings, it may not be ethical, culturally appropriate, or practical to request that water be supplied by the household, especially if water is scarce.

PSEM	Equipment, tools, and aids required[B]	Use of PSEM during the 24-hour dietary recall		Measurement unit in which the portion size data are collected
		Steps to be undertaken by the respondent[C]	Steps to be undertaken and recorded by the enumerator[D]	
5. **Proxy weight using a material that heaps** (e.g., Kinetic Sand®)[K]	Kinetic Sand® (or other suitable proxy material) High-quality digital dietary scales (along with high-quality batteries and certified standard weights for scale testing) Commonly used spoons, scoops, and/or ladles; and a cup or bowl Storage containers	The Kinetic Sand® is scooped with a spoon, scoop, or ladle into a cup or bowl to represent the amount consumed. Ideally, the same spoon, scoop, or ladle used by the respondent is used when estimating the portion size consumed.	The Kinetic Sand® is weighed on a digital dietary scale and the weight is recorded to the nearest gram.	Grams of proxy material
6. **Calibrated household utensils** (e.g., spoons, scoops, ladles)[L]	Set of spoons, scoops, and/or ladles of a range of sizes with a pre-determined volume	A spoon, scoop, or ladle most similar to the one used by the respondent is selected from a range of sizes. If relevant, the number (multiples) of the selected unit is reported.	The code of the spoon, scoop, or ladle selected is recorded. The number of units reported is recorded.	Volume of the selected utensil
Group II PSEMs: Methods that require extensive preparatory work in advance of the survey				
7. **Graduated portion-size food photographs** depicting multiple portion sizes for a given food item	Photographic series (each image corresponds to a known weight of the depicted food item)	The image that most closely represents the amount of the food item consumed is selected from a set of images in a photographic series. Depending on survey operationalization, the number (multiples) and/or fractions of the selected portion size can be reported. Alternatively, portion sizes between two images can be reported. Depending on survey operationalization, substitutions may be allowed.[F]	The code of the image selected is recorded (or if relevant, the code that corresponds to a portion size not depicted). If relevant, the number and/or fraction of the selected image is recorded. If relevant, substitutions are recorded.	Grams of the portion size selected

[B] In addition to the equipment, tools, and aids listed in this table, a PSEM list should be developed by survey planners to specify the PSEMs assigned to each item in the FRIL to guide the enumerator during the 24-hour dietary recall interview.

[C] For simplicity, we refer to food items consumed, but several PSEMs can also be used to estimate the amount of an ingredient used and the total amount of a mixed dish prepared.

[D] For food items for which amounts consumed can be estimated with the inedible portions included (e.g., chicken, fish, and other meat served with bone), the enumerator must always record if inedible parts were included or not when estimating the amount consumed.

[F] Whether and for what foods the use of substitutions is allowed depends on the survey context; these decisions must be made before data collection.

[K] Kinetic Sand® is the most suitable proxy material to use for this PSEM because it is easy to handle and safe to use, retains a constant density, and heaps well. However, Kinetic Sand® can be expensive and difficult to procure in some settings. Because of the variability that is possible in the level of packing by respondents when using Kinetic Sand® as a proxy material, *Intake* recommends only using Kinetic Sand® for scooping and heaping and not for any molding of shapes.

[L] This PSEM may also be referred to as "household measures," which typically includes the use of calibrated bowls and cups. However, the PSEM described here is intended to be used only for liquid food items typically consumed in small quantities and is therefore different. We do not include the use of bowls and cups among calibrated household utensils to be used as a PSEM because of the different considerations the use of bowls and cups would require for how to operationalize this PSEM.

PSEM	Equipment, tools, and aids required[B]	Use of PSEM during the 24-hour dietary recall		Measurement unit in which the portion size data are collected
		Steps to be undertaken by the respondent[C]	Steps to be undertaken and recorded by the enumerator[D]	
8. **Full-size food photographs** depicting multiple unit sizes of a food in a whole, unprocessed state	Photographic series (each image corresponds to a known weight of the depicted food)	The image that most closely represents the unit size of the food served is selected from a set of images in photographic series. The number (multiples) and/or fractions consumed of the selected unit size depicted are reported.	The code of the image selected is recorded. The number and/or fraction of the selected image is recorded.	Grams of the unit size selected
9. **2D shapes** depicting multiple unit sizes for a given food item	2D shapes, such as drawings, photographs, or cardboard cutouts (each shape with a given area [e.g., length and width in the case of a square or rectangular shape] corresponds to a known weight of a given food item)	The 2D shape that most closely represents the unit size of the food item served is selected from a range of sizes. The number (multiples) and/or fractions consumed of the selected unit size depicted are reported.	The code of the 2D shape selected is recorded. The number and/or fraction of the selected 2D shape is recorded.	Grams of the unit size selected
10. **3D food models** depicting multiple unit sizes for a given food item	3D food models of variable sizes for a given food item, made from plastic or other durable material (each model corresponds to a known weight of a given food item)	The 3D food model that most closely represents the unit size of the food item served is selected from a range of sizes. The number (multiples) and/or fractions consumed of the selected unit size depicted are reported.	The code of the 3D food model selected is recorded. The number and/or fraction of the selected 3D food model is recorded.	Grams of the unit size selected

[B] In addition to the equipment, tools, and aids listed in this table, a PSEM list should be developed by survey planners to specify the PSEMs assigned to each item in the FRIL to guide the enumerator during the 24-hour dietary recall interview.

[C] For simplicity, we refer to food items consumed, but several PSEMs can also be used to estimate the amount of an ingredient used and the total amount of a mixed dish prepared.

[D] For food items for which amounts consumed can be estimated with the inedible portions included (e.g., chicken, fish, and other meat served with bone), the enumerator must always record if inedible parts were included or not when estimating the amount consumed.

2 PSEM Conversion Factors for Foods

A PSEM conversion factor for a given food consists of two components:

- A **PSEM-specific factor** which relates directly to the PSEM used to assess the amount of a specific food reported as consumed
- An **edible portion factor** needed to account for any inedible portion included in the amount of that food estimated as consumed by the respondent

In this section, we describe each of these components for foods (including beverages and ingredients of mixed dishes) estimated with Group I and Group II PSEMs. We first describe the data needed to derive the PSEM-specific factor (Section 2.1) and the edible portion factor (Section 2.2) for a given food. Then we discuss how to combine the two components to derive the PSEM conversion factor used for data processing (Section 2.3). Lastly, we describe the additional conversion required if substitutions[5] are allowed for any foods when using direct weight or graduated portion-size food photographs as a PSEM (Section 2.4).

2.1 PSEM-Specific Factors for Foods

The PSEM-specific factor needed for a given food depends on the PSEM method used for estimating the amount consumed and the unit with which that PSEM collects information about the portion size consumed (as shown in the last column of Table 1). The data needed to derive PSEM-specific factors for each Group I and Group II PSEM are described below. The calculations needed to derive the PSEM-specific factor for each Group I and Group II PSEM are shown in Table 3 (see the column labeled "PSEM-specific factor").

Direct weight

The only PSEM that does not require the compilation of a PSEM-specific factor to derive the grams consumed of the food reported is direct weight. This is because the amount of food replica representing the food consumed is weighed directly in grams. Therefore, when using direct weight, the PSEM-specific factor is set to 1.[6]

Standard unit size

With the use of standard unit size as a PSEM, the respondent reports the number and/or fractions of a standard unit size consumed of a given food. The PSEM-specific factor, in this case, is the corresponding gram weight of the standard unit size.

Proxy weight

Three Group I PSEMs rely on the respondent using a proxy material (i.e., playdough, raw rice, and Kinetic Sand®) to represent the amount of the actual food consumed. When the respondent estimates the amount consumed using the proxy material, what s/he is visualizing is the volume of the proxy material equivalent to the volume of the actual food that was consumed. Because (with very few exceptions) the proxy material and the actual food consumed do not have equal densities, the weight of the proxy material will not be equal to the weight of the actual food consumed. Therefore, the weight of the proxy material measured during the 24-hour dietary recall interview needs to be converted into the corresponding weight of the food reported as consumed; this conversion is done with a PSEM-specific factor.

[5] Substitutions refers to using a PSEM developed for use with a specific food item to estimate the portion size consumed for a set of similar food items that are not represented or depicted (e.g., use of graduated portion-size food photographs depicting cooked spinach to assess the amount of cooked kale consumed). Survey planners can consider the use of substitutions when using direct weight and graduated portion-size food photographs as PSEMs.

[6] If survey planners decide to allow the use of substitutions with direct weight as a PSEM, then a substitution factor will be needed. See Section 2.4.

The PSEM-specific factor for a given food is calculated by dividing the density of the food reported as consumed by the respondent by the density of the proxy material used to estimate the amount consumed (e.g., playdough, raw rice, Kinetic Sand®). This approach is referred to as the "preferred approach" and requires obtaining accurate density data for both the food and the proxy material. The preferred approach should always be used for foods estimated using raw rice or Kinetic Sand® because the nature of the foods estimated using these materials allows for determining the density of the food. It can also be used for foods estimated using playdough when it is feasible to determine the density of the food (i.e., free-flowing foods and relatively small solid foods that do not absorb water).

For foods estimated using playdough for which it is not feasible to obtain accurate data on food density,[7] an "alternative approach" can be used to derive the PSEM-specific factor. The alternative approach entails weighing a visually equal volume of playdough and a sample of the food for which the PSEM-specific factor needs to be estimated. Using this approach, the PSEM-specific factor for a given food is calculated by dividing the weight of the food by the weight of the same volume of the proxy material.

Calibrated household utensils

The use of calibrated household utensils (e.g., spoons, scoops, ladles) entails the respondent selecting a utensil with a pre-determined volume and reporting the number of level measurements of that utensil that represents the amount of a given food consumed. Deriving the PSEM-specific factor for calibrated household utensils requires converting the volume of the utensil selected by the respondent into the weight of the food reported as consumed. This is done by using information on the density of that food. The PSEM-specific factor for a given food is calculated by multiplying the pre-determined volume of the utensil selected by the respondent by the density of the food consumed.

Food photographs, 2D shapes, and 3D food models

When using Group II PSEMs, the respondent is asked to select the portion size (in the case of graduated portion-size food photographs) or unit size (in the case of full-size food photographs, 2D shapes, and 3D food models) of the food that most closely represents the amount consumed (in the case of graduated portion-size food photographs) or the amount served (in the case of full-size food photographs, 2D shapes, and 3D food models). If relevant, and depending on how the PSEM is operationalized for a given survey, the respondent reports the number and/or fractions of the selected portion or unit size or a different portion size than those depicted (e.g., a quantity in-between two of the portion sizes depicted in the photographic series). The PSEM-specific factor is the pre-determined weight of the food depicted in the food photograph,[8] 2D shape, or 3D food model series (or if relevant, the portion size not depicted).

2.2 Edible Portion Factors for Foods

Many foods include inedible parts that may or may not be removed before the food is served. When a food is served with inedible parts, it may be easier for the respondent to visualize and report the amount consumed with the inedible portion included. For such foods, survey planners should include forms and presentation modes of that food with the inedible portion included in the FRIL. Examples of foods for which the amount consumed may be easier for respondents to visualize with the inedible parts included are chicken, fish, and other meat served with the bone; groundnuts in the shell; maize on the cob; and fruits with inedible seeds, pits, or peels.

During the 24-hour dietary recall interview, the enumerator must establish if the food reported for which the portion size is being estimated includes inedible parts. The enumerator should be guided by food-specific probes to ask for this information when relevant. If the food reported by the respondent could be served with an inedible

[7] As described in Section 4.1.1, density data for foods can either be derived by filling a measuring cup or by submerging the food item into water to measure the water displacement. Neither of these methods are feasible to use for foods that do not fit into a measuring cup because they are large or awkwardly shaped and that cannot be submerged in water because they absorb water (e.g., bread, pizza).

[8] If survey planners decide to allow the use of substitutions when using graduated portion-size food photographs, then a substitution factor will be needed. See Section 2.4.

portion, the enumerator must establish if the respondent is estimating the amount consumed with or without the inedible portion.

Not all Group I and Group II PSEMs are suitable for the estimation of foods including inedible parts (see Table 2). Direct weight, graduated portion-size food photographs, and 2D shapes are not suitable to estimate amounts of foods that are visualized including inedible parts. Likewise, proxy weight using a material that heaps (e.g., Kinetic Sand®) and calibrated household utensils are typically used only for foods that do not include inedible portions (such as free-flowing solids and liquids). The remaining PSEMs, namely standard unit size, proxy materials, full-size food photographs, and 3D food models, are suitable for the estimation of foods that include inedible parts.

During data processing, any inedible part included in the estimation of the amount consumed will need to be accounted for, to derive the amount of edible food consumed, which is what is needed for the analysis of the data. The conversion from an amount estimated that included inedible parts into the corresponding amount of food consumed is done using a pre-defined edible portion factor. The edible portion factor is a value >0 and ≤1, reflecting the proportion of a food that is typically eaten.

Every food in the FRIL should have an associated edible portion factor listed in the PSEM conversion factor database. The edible portion factor is set to 1 for foods that do not have inedible parts (i.e., when the entire food is edible) and for foods for which the amount consumed is estimated by the respondent without any inedible parts (i.e., the inedible parts were not included in the portion size estimation).

Table 2. Edible Portion Factor Guidance for Foods That May Include Inedible Parts, by PSEM[A,B]

PSEM	How the amount consumed is reported by the respondent	Edible portion factor
Group I PSEMs: Methods that do not require extensive preparatory work in advance of the survey		
1. **Direct weight** using food replicas	This PSEM should be used only for foods served without inedible parts.	The edible portion factor is set to 1.
2. **Standard unit size** (each unit corresponds to a known weight)	With this PSEM, foods can be estimated with inedible parts included or excluded.	If the food is estimated with inedible parts included, an edible portion factor for the food must be compiled.
		If the food is estimated without inedible parts included, the edible portion factor is set to 1.
3. **Proxy weight using a material that can be shaped** (e.g., playdough)	With this PSEM, foods can be estimated with inedible parts included or excluded.	If the food is estimated with inedible parts included, an edible portion factor for the food must be compiled.
		If the food is estimated without inedible parts included, the edible portion factor is set to 1.

[A] This table is adapted from Table 3 in Vossenaar M, Lubowa A, Hotz C, Deitchler M, Moursi M, Arimond M, Crispim SP, and Arsenault J. 2020. *Considerations for the Selection of Portion Size Estimation Methods for Use in Quantitative 24-Hour Dietary Recall Surveys in Low- and Middle-Income Countries.* Washington, DC: *Intake* – Center for Dietary Assessment/FHI Solutions. Available at Intake.org.

[B] Cells shaded in grey represent PSEMs for which the edible portion factor is always set to 1, and cells shaded in teal represent PSEMs for which the edible portion factor is set to 1 when the food item is estimated without inedible parts included.

PSEM	How the amount consumed is reported by the respondent	Edible portion factor
4. **Proxy weight using a free-flowing material** that is pourable (e.g., raw rice)	With this PSEM, foods can be estimated with inedible parts included or excluded.	If the food is estimated with inedible parts included, an edible portion factor for the food must be compiled.
		If the food is estimated without inedible parts included, the edible portion factor is set to 1.
5. **Proxy weight using a material that heaps** (e.g., Kinetic Sand®)	This PSEM should be used only for small quantities of foods that can be visualized with calibrated household utensils, such as spoons, scoops, and ladles. Such foods do not include inedible parts.	The edible portion factor is set to 1.
6. **Calibrated household utensils** (e.g., spoons, scoops, ladles)	This PSEM should be used only for liquid foods. Such foods do not include inedible parts.	The edible portion factor is set to 1.
Group II PSEMs: Methods that require extensive preparatory work in advance of the survey		
7. **Graduated portion-size food photographs** depicting multiple portion sizes for a given food	This PSEM should be used only for food items served without inedible parts.	The edible portion factor is set to 1.
8. **Full-size food photographs** depicting multiple unit sizes of a food in a whole, unprocessed state	If the food includes inedible parts, this PSEM is appropriate to use only for the form of that food that is served or used with inedible parts included.	If the food is estimated with inedible parts included, an edible portion factor for the food must be compiled.
	If the food does not have inedible parts, this PSEM is appropriate to use only for the form of that food that is served or used without inedible parts included.	If the food is estimated without any inedible parts, the edible portion factor is set to 1.
9. **2D shapes** depicting multiple unit sizes for a given food	This PSEM should be used only for foods served without inedible parts.	The edible portion factor is set to 1.
10. **3D food models** depicting multiple unit sizes for a given food	If the food model represented includes inedible parts, this PSEM is appropriate to use only for the form of that food that is served or used with inedible parts included.	If the food is estimated with inedible parts included, an edible portion factor for the food must be compiled.
	If the food model represented excludes inedible parts, this PSEM is appropriate to use only for the form of that food that is served or used without inedible parts included.	If the food is estimated without inedible parts included, the edible portion factor is set to 1.

[A] This table is adapted from Table 3 in Vossenaar M, Lubowa A, Hotz C, Deitchler M, Moursi M, Arimond M, Crispim SP, and Arsenault J. 2020. *Considerations for the Selection of Portion Size Estimation Methods for Use in Quantitative 24-Hour Dietary Recall Surveys in Low- and Middle-Income Countries.* Washington, DC: *Intake* – Center for Dietary Assessment/FHI Solutions. Available at Intake.org.

[B] Cells shaded in grey represent PSEMs for which the edible portion factor is always set to 1, cells shaded in teal represent PSEMs for which the edible portion factor is set to 1 when the food item is estimated without inedible parts included.

2.3 Data Processing of Foods Using PSEM Conversion Factors

The PSEM conversion factor for a food in a given state, form, and presentation mode is calculated by multiplying the PSEM-specific factor by the edible portion factor. During data processing, the PSEM conversion factor is multiplied by the portion size data collected during the quantitative 24-hour dietary recall survey (e.g., the weight of food replica; the number and/or fraction of standard units consumed; the weight of proxy material; the number of the household utensil selected; the number and/or fraction of the graduated portion-size food image selected; the number and/or fraction of the selected full-size food image, 2D shape, 3D food model) to derive the grams of edible food consumed.

An overview of the calculations required to derive the PSEM conversion factor is provided in the right-most column of Table 3 for each Group I and Group II PSEM. These calculations are valid for estimating intake amounts of all foods and beverages, and ingredients added to mixed dishes. Supplementary File 1 provides example calculations for converting the portion size data reported by a respondent for a given food estimated using a pre-determined PSEM, into grams of edible food consumed.

Table 3. Calculations to Derive the Gram Weight of Edible Food Consumed, by PSEM

PSEM	Data recorded during 24-hour recall	PSEM Conversion Factor (calculated by multiplying the PSEM-specific factor by the edible portion factor)		Calculation to derive grams of edible food consumed[A]
		PSEM-specific factor	Edible portion factor	
Group I PSEMs: Methods that do not require extensive preparatory work in advance of the survey				
1. **Direct weight** using food replicas[B]	Weight (g) of food replica	The PSEM-specific factor is set to 1	The edible portion factor is set to 1[C]	PSEM conversion factor × weight of food replica
2. **Standard unit size** (each unit corresponds to a known weight)	Number and/or fraction of units consumed	Grams per unit	Edible portion factor	PSEM conversion factor × number and/or fraction of units consumed
3. **Proxy weight using a material that can be shaped** (e.g., playdough)	Weight (g) of proxy material and, if relevant, number of units consumed	*Preferred approach:* Density of the food (g/ml) ÷ density of the proxy material (g/ml)[D]	Edible portion factor	PSEM conversion factor × weight of proxy material (× number of units consumed)
		Alternative approach: Weight of the food (g) ÷ weight of the same volume of the proxy material (g)[E]		

[A] For convenience, the term "grams of edible food consumed" is used to describe the calculation, but the outcome of the calculation may also be "grams of edible ingredient used" or "grams of edible recipe prepared."

[B] Additional conversions are required when substitutions are allowed. The calculations required for this additional conversion are shown in Table 4.

[C] Food items estimated using this PSEM should not include any inedible parts.

[D] The preferred approach is recommended to derive the PSEM-specific factor when accurate density data for the reported food can be obtained.

[E] The alternative approach can be used to derive the PSEM-specific factor when it is not feasible to obtain accurate density data for the reported food.

PSEM	Data recorded during 24-hour recall	PSEM Conversion Factor (calculated by multiplying the PSEM-specific factor by the edible portion factor)		Calculation to derive grams of edible food consumed[A]
		PSEM-specific factor	Edible portion factor	
4. **Proxy weight using a free-flowing material that is pourable** (e.g., raw rice)	Weight (g) of proxy material and, if relevant, number of units consumed	Density of the food (g/ml) ÷ density of the proxy material (g/ml)	Edible portion factor	PSEM conversion factor × weight of proxy material (× number of units consumed)
5. **Proxy weight using a material that heaps** (e.g., Kinetic Sand®)	Weight (g) of proxy material	Density of the food (g/ml) ÷ density of the proxy material (g/ml)	The edible portion factor is set to 1[C]	PSEM conversion factor × weight of proxy material
6. **Calibrated household utensils** (e.g., spoons, scoops, ladles)	Utensil code and number of units consumed	Volume of utensil (ml)[F] × density of food (g/ml)	The edible portion factor is set to 1[C]	PSEM conversion factor × number of units consumed
Group II PSEMs: Methods that require extensive preparatory work in advance of the survey				
7. **Graduated portion-size food photographs** depicting multiple portion sizes for a given food[B]	Photograph code and, if relevant, number and/or fraction of units consumed[G]	Grams of the portion size depicted	The edible portion factor is set to 1[C]	PSEM conversion factor (× number and/or fraction of units consumed)
8. **Full-size food photographs** depicting multiple unit sizes of a single food in a whole, unprocessed state	Photograph code and number and/or fraction of units consumed	Grams of the unit size depicted	Edible portion factor	PSEM conversion factor × number and/or fraction of units consumed
9. **2D shapes** depicting multiple unit sizes for a given food	2D shape code and number and/or fraction of units consumed	Grams of the unit size depicted	The edible portion factor is set to 1[C]	PSEM conversion factor × number and/or fraction of units consumed
10. **3D food models** depicting multiple unit sizes for a given food	3D food model code and number and/or fraction of units consumed	Grams of the unit size depicted	Edible portion factor	PSEM conversion factor × number and/or fraction of units consumed

[A] For convenience, the term "grams of edible food consumed" is used to describe the calculation, but the outcome of the calculation may also be "grams of edible ingredient used" or "grams of edible recipe prepared."

[B] Additional conversions are required when substitutions are allowed. The calculations required for this additional conversion are shown in Table 4.

[C] Food items estimated using this PSEM should not include any inedible parts.

[F] The density of water is 1. Therefore, the volume of the spoon is equal to the weight of the water when the spoon is filled with water.

[G] If allowed after careful consideration.

2.4 Additional Conversions Required for Food Substitutions

In some survey contexts, survey planners may decide to allow the PSEM developed for a specific food to be used to estimate portion sizes of a set of similar foods; this is referred to as the use of substitutions. The only PSEMs for which substitutions are relevant to consider are direct weight and graduated portion-size food photographs. For example, when using direct weight as a PSEM, cooked fava beans might be used as a food replica to estimate the amount of cooked kidney beans consumed, or when using graduated portion-size food photographs, a photo series depicting different portion sizes of cooked spinach might be used to assess the amount of cooked kale consumed.

The use of substitutions with direct weight or graduated portion-size food photographs requires following a set of strict criteria for the selection of foods that will be allowed to be used as substitutions with the PSEM assigned to a given food.[9] The specific substitutions that are allowed with each PSEM and food must be decided by survey planners and well-documented for enumerators in advance of data collection.

When substitutions are allowed, an additional conversion factor (referred to as the "substitution factor") is required to translate the portion size represented by the food replica or in the graduated portion-size food photographs into the portion size of the substitution food (i.e., the actual food reported as consumed).

When using substitutions, the following data are needed to derive the substitution factor:

- The density of the substitution food
- The density of the food replica (applies to direct weight)
- The density of the food depicted in the food photograph (applies to graduated portion-size food photographs)

Table 4 provides an overview of the calculations required to account for substitutions. A calculation example is shown in Box 1.

Table 4. Calculations to Determine the Gram Weight of Edible Food Consumed When Allowing Substitutions, by PSEM

PSEM	Data recorded during 24-hour recall	PSEM Conversion Factor (calculated by multiplying the "PSEM-specific factor" by the "edible portion factor")		Substitution factor	Calculation to determine grams of edible food consumed
		PSEM-specific factor	Edible portion factor		
Group I PSEMs: Methods that do not require extensive preparatory work in advance of the survey					
1. **Direct weight** using food replicas	Weight (g) of food replica	The PSEM-specific factor is set to 1	The edible portion factor is set to 1[A]	Density of the substitution food (g/ml) ÷ density of the food replica (g/ml)	PSEM conversion factor × weight of food replica × substitution factor
Group II PSEMs: Methods that require extensive preparatory work in advance of the survey					
7. **Graduated portion-size food photographs** depicting multiple portion sizes for a given food	Photograph code and, if relevant, number and/or fraction of units consumed[B]	Grams of the portion size depicted	The edible portion factor is set to 1[A]	Density of the substitution food (g/ml) ÷ density of the food depicted (g/ml)	PSEM conversion factor (× number and/or fraction of units consumed) × substitution factor

[A] Foods estimated using this PSEM should not include any inedible parts.

[B] If allowed after careful consideration.

[9] For detailed guidance related to criteria for allowed substitutions, see Section 4.1.5 in Vossenaar M, Lubowa A, Hotz C, Deitchler M, Moursi M, Arimond M, Crispim, SP, and Arsenault J. 2020. *Considerations for the Selection of Portion Size Estimation Methods for Use in Quantitative 24-Hour Dietary Recall Surveys in Low- and Middle-Income Countries*. Washington, DC: *Intake* – Center for Dietary Assessment/FHI Solutions. Available at: Intake.org.

Box 1. Example: Use of PSEM Conversion Factors With and Without a Substitution Factor to Derive Grams of Edible Food Consumed

		Example with a substitution Fava beans are used to estimate kidney beans	**Example without a substitution** Fava beans are used to estimate fava beans
Reported food and PSEM used	Reported food:	Cooked fava beans (no inedible parts included)	Cooked kidney beans (no inedible parts included)
	PSEM used:	Direct weight using cooked fava beans as food replica	Direct weight using cooked fava beans as food replica
Data collected	Weight of food replica:	388 g	388 g
Data needed to calculate the PSEM conversion factor	PSEM-specific factor:[A]	None because set to 1	None because set to 1
	Edible portion factor:[B]	None because set to 1	None because set to 1
Data needed to calculate the substitution factor	Density of the food replica:	None because no substitution factor is needed	1.39 g/ml
	Density of the substitution food consumed:	None because no substitution factor is needed	1.32 g/ml
PSEM conversion factor calculation	PSEM conversion factor:[C]	1 x 1.0 = 1	1 x 1.0 = 1
	Substitution factor:	None because no substitution factor is needed	1.32 ÷ 1.39 = 0.95[D]
Calculation using the PSEM conversion factor and, if relevant, the substitution factor	Amount of food consumed (edible portion)	388 x 1 = **388 g**[E]	388 x 1 x 0.95 = **368 g**[F]

[A] The amount of food replica representing the food item consumed is weighed directly in grams. Therefore, no conversion is needed and the PSEM-specific factor is set to 1.

[B] Food items estimated using direct weights as PSEM should not include any inedible parts; therefore the edible portion factor is set to 1.

[C] The calculation used is "PSEM-specific factor" x "Edible portion factor".

[D] The calculation used is "density of the substitution food item (g/ml)" ÷ "density of the food replica (g/ml)".

[E] The calculation used is "grams reported as consumed" x "PSEM conversion factor".

[F] The calculation used is "grams reported as consumed" x "PSEM conversion factor" x "substitution factor".

3 PSEM Conversion Factors for Mixed Dishes

Recipe data collected for mixed dishes should be disaggregated to the ingredient level for use in data analysis; this allows for food-based dietary analyses such as estimating the usual intake distribution of specific foods and food groups consumed (e.g., fruits and vegetables) and the energy and nutrient contribution of these foods to the diet (e.g., main food sources of iron). When a mixed dish is reported, recipe calculations[10] are applied to disaggregate the amount of mixed dish consumed into the edible amount of each ingredient. The recipe calculation steps and required PSEM conversion factors vary depending on whether the mixed dish consumed is a mixed dish for which a standard recipe is available.[11]

When a standard recipe is used, the only PSEM conversion factor needed for data processing is to convert the amount of the mixed dish consumed estimated during the quantitative 24-hour dietary recall survey using a PSEM (e.g., the weight of proxy material) into the gram amount of mixed dish consumed. When a non-standard recipe[12] is used, additional PSEM conversion factors are needed.

In this section, we provide guidance on how to derive PSEM-specific factors for standard and non-standard recipes (Section 3.1) and make a distinction between homogenous[13] and non-homogenous[14] mixed dishes (Section 3.2). We also describe how inedible portions are accounted for in mixed dishes (Section 3.3) and how PSEM conversion factors are applied during data processing of mixed dishes (Section 3.4). Lastly, we describe the additional conversion required if substitutions are allowed for mixed dishes when using direct weight or graduated portion-size food photographs as a PSEM (Section 3.5).

3.1 PSEM-Specific Factors for Mixed Dishes with or without Standard Recipes

The vast majority of large-scale 24-hour dietary recall surveys use a combination of standard and non-standard recipes during data collection. Key concepts related to the use of standard and non-standard recipes are summarized in Box 2.

[10] For detailed guidance on the collection and analysis of recipe data in dietary surveys, *see* Vossenaar M, Hotz C, Lubowa A, Deitchler M, Moursi M, Arsenault J, Colaiezzi B, and Arimond M. 2022. *Guidance for the Use of Standard and Non-Standard Recipes in Quantitative 24-Hour Dietary Recall Surveys: The Simple Ingredient Method.* Washington, DC: *Intake* – Center for Dietary Assessment/FHI Solutions. Available at Intake.org.

[11] A standard recipe is an "average" recipe that aims to reflect the way that a mixed dish is usually prepared by respondents in a survey area. Standard recipes can be used for mixed dishes that are known to be prepared similarly across a defined survey area (in terms of the ingredients used, the preparation methods for those ingredients and the mixed dish itself, and the relative proportion of each ingredient used in the mixed dish). Standard recipes are also typically used when survey respondents report consuming mixed dishes prepared outside the home (e.g., by vendors or in restaurants, in "ready meals" purchased from stores).

[12] A non-standard recipe is a recipe derived from data collected in the household during the 24-hour dietary recall interview. During the interview, the respondent and/or the cook of the mixed dish, provides the details of the mixed dish consumed by the respondent; these include a detailed description of the ingredients and the amounts used, the total amount of the mixed dish prepared, and the amount of the mixed dish consumed.

[13] A homogenous mixed dish is a mixed dish in which all ingredients are more or less evenly distributed. Any serving from a mixed dish contains similar proportions of the constituent ingredients.

[14] A non-homogenous mixed dish is a mixed dish in which ingredients are not evenly distributed. Any serving from a mixed dish does not necessarily contain similar proportions of the constituent ingredients. Typically, non-homogenous mixed dishes refer to dishes in which the ingredients that are not evenly distributed in the mixture are nutrient-dense (e.g., chunks of red meat, fish, or poultry in a stew).

Box 2. Key Concepts Related to the Use of Standard and Non-Standard Recipes

Standard Recipes

- Standard recipes aim to reflect the way that mixed dishes are usually prepared by respondents and are often developed in advance of data collection for mixed dishes that are commonly consumed by members of the target population for the survey.
- Standard recipe data include descriptive details about the ingredients used in the mixed dish, the method of preparation for each ingredient, the relative proportion of each ingredient added to the mixed dish, and any preparation method applied to the mixed dish.
- When a mixed dish with a standard recipe is reported during the 24-hour dietary recall interview, only the amount of the mixed dish consumed by the respondent needs to be estimated.
- All Group I and Group II PSEMs except for full-size food photographs can be used to estimate the amount consumed of a mixed dish for which a homogenous standard recipe has been developed. However, not all PSEMs are suitable for non-homogenous mixed dishes. Also, direct weight, proxy weight using a material that heaps, calibrated household utensils, graduated portion-size food photographs, full-size food photographs and 2D shapes are not suitable PSEMs to estimate amounts of mixed dishes that include inedible parts.[A]

Non-Standard Recipes

- When a standard recipe is not available for a mixed dish reported, the enumerator must collect detailed information about the preparation of that mixed dish during the 24-hour dietary recall interview to derive a non-standard recipe.
- To collect data for a non-standard recipe, data must be collected from the respondent and/or cook on the ingredients used in the mixed dish, the method of preparation for each ingredient, and any preparation method applied to the mixed dish.
- In addition, the following amounts must be estimated by the respondent and/or cook:
    - The amount of each ingredient used to prepare the mixed dish
    - The total amount of the mixed dish prepared
    - The amount of the mixed dish consumed by the respondent
    - For mixed dishes for which a standard recipe is not available, *Intake* recommends using (i) the same PSEM to estimate the amount of total mixed dish prepared and the amount of the mixed dish consumed (to bypass the need for a PSEM-specific factor for the mixed dish), (ii) a Group I PSEM for portion size estimation (group II PSEMs require preparatory work in advance of data collection which cannot be done without knowing the mixed dish), and (iii) a PSEM that is suitable to estimate larger quantities.
    - The two most suitable PSEMs that meet these criteria are proxy weight using a free-flowing material that is pourable (e.g., raw rice) and proxy weight using a material that can be shaped (e.g., playdough).

Standard and Non-Standard Recipes

- During data processing, the mixed dish is disaggregated into its separate constituent ingredients, which allows for estimating the corresponding amount of edible portion of each ingredient consumed in grams.
- If the mixed dish includes inedible parts, these are accounted for at the ingredient level during recipe processing.

[A] For an overview of the suitability of PSEMs for mixed dishes, see Table 2 in Vossenaar M, Lubowa A, Hotz C, Deitchler M, Moursi M, Arimond M, Crispim SP, and Arsenault J. 2020. *Considerations for the Selection of Portion Size Estimation Methods for Use in Quantitative 24-Hour Dietary Recall Surveys in Low- and Middle-Income Countries*. Washington, DC: *Intake* – Center for Dietary Assessment/FHI Solutions. Available at: Intake.org.

One advantage of using standard recipes is that only the amount of the mixed dish consumed by the respondent needs to be estimated during the 24-hour dietary recall interview. The standard recipe data (i.e., average ingredient proportions) collected in advance of 24-hour dietary recall data collection are used to derive the edible amount of each ingredient consumed. Box 3 provides an example to illustrate how the gram amount consumed of each ingredient in a mixed dish is calculated when a standard recipe is available.

When using non-standard recipes, besides estimating the amount of the mixed dish consumed, the cook and/or respondent must also estimate the amount of each ingredient used to prepare the mixed dish and the amount of the mixed dish prepared during the 24-hour dietary recall interview. To estimate each of these amounts, separate PSEM-specific factors are needed. In a comprehensive PSEM conversion factor database, PSEM-specific factors are typically already available for each of the ingredients used in a mixed dish. However, it is not possible to compile the PSEM-specific factor for the mixed dish itself in advance of data collection. This is because the recipe for a mixed dish encountered during the survey (and for which a standard recipe was not developed in advance of the survey) is unknown until the time of data collection with the respondent.

To avoid unnecessary complications in compiling the PSEM-specific factor for non-standard recipes, *Intake* recommends using the same PSEM to estimate the amount of total mixed dish prepared and the amount of the mixed dish consumed. When this is done, the need to derive a PSEM-specific factor for the mixed dish is bypassed.

Box 4 provides an example of the use of PSEM-specific factors needed to calculate the grams of each ingredient consumed for a mixed dish with a non-standard recipe. To illustrate the advantage of using the same PSEM to estimate the amount of total mixed dish prepared and the amount of the mixed dish consumed, two different scenarios are presented. Scenario A shows the PSEM-specific factors that would be needed to derive the amount of each ingredient consumed when different PSEMs are used to estimate the amount of total mixed dish prepared and the amount of the mixed dish consumed. The challenge of this calculation is that the PSEM-specific factor for a prepared mixed dish without a standard recipe cannot be derived until after the collection of 24-hour dietary recall data. Scenario B, which is the approach recommended by *Intake*, shows how this challenge can be overcome by using the same PSEM to estimate both the amount of total mixed dish prepared and the amount of the mixed dish consumed. When this is done, the weight of the total mixed dish prepared and the amount of the mixed dish consumed are not calculated and PSEM-specific factors for these quantities are not needed. Instead, recipe calculations are done in the units of the PSEM used to estimate these amounts (e.g., grams of raw rice that represent the total mixed dish prepared and grams of raw rice that represent the amount of mixed dish consumed).

Box 3. Example: The Use of PSEM Conversion Factors for Standard Recipes

Context

During a 24-hour dietary recall interview, groundnut sauce is reported and standard recipe data is collected in advance of data collection for the survey.

Data collection and processing before data collection for the survey

The data needed to derive the PSEM-specific factor and average ingredient proportions for a standard recipe are typically collected during cooking sessions or from or from vendors and restaurants, often in advance of data collection for the survey

Average ingredient proportions are calculated by dividing the weight of the ingredient in the form in which it was added to the mixed dish (raw in this example) by the weight of the total amount of groundnut sauce prepared (cooked in this example).

Data collected during the 24-hour dietary recall interview

The respondent is asked to estimate the amount of groundnut sauce consumed using a pre-determined PSEM. The amounts of ingredients used to prepare the groundnut sauce and the total amount of groundnut sauce prepared do not need to be estimated.

Data processing after data collection for the survey

Step 1: A PSEM conversion factor for the standard recipe is used to estimate the amount of groundnut sauce consumed.

PSEM	Data collected using a PSEM	PSEM conversion factor		Calculated amount of mixed dish consumed
		PSEM-specific factor	Edible portion factor	
Calibrated household utensils	2 ladles	40	1[A]	80 g

[A] Because inedible portions of mixed dishes are accounted for at the ingredient level during recipe calculations, the edible portion factor for the mixed dish is always set to 1.

Step 2: The amount of each ingredient consumed is calculated by multiplying the amount of groundnut sauce consumed with the average ingredient proportion for that specific ingredient.

Ingredient[A]	Average ingredient proportion (gram to gram ratio)[B]	Calculated amount of ingredient consumed
Groundnuts, raw	0.520	80 x 0.520 = 42 g
Chopped tomato, raw	0.068	80 x 0.068 = 5 g
Onion, raw	0.097	80 x 0.097 = 8 g
Ginger, raw	0.018	80 x 0.018 = 1 g

[A] Although this recipe is prepared with water, the amount of water is not estimated.

[B] Average ingredient proportions (gram to grams ratio) are calculated in advance of data collection by dividing the weight of the ingredient in the form in which it was added to the mixed dish (raw in this example) by the weight of the total amount of mixed dish prepared. Note that these proportions do not add up to 1 because water as an ingredient and water loss during cooking is not accounted for.

Box 4. Example: The Use of PSEM Conversion Factors for Non-Standard Recipes

Context

During a 24-hour dietary recall interview, groundnut sauce is reported and non-standard recipe data are collected.

Data collection and processing before data collection for the survey

None.

Scenario A (not recommended): Different PSEMs are used to estimate the amount of mixed dish prepared and the amount of mixed dish consumed by the respondent

Data collected during the 24-hour dietary recall interview

The respondent and/or the cook is asked to estimate the amount of:

- Each ingredient used to prepare the groundnut sauce (in the form added to the mixed dish) using various PSEMs (raw rice for groundnuts; raw rice for chopped tomato, raw; full-size food photograph for onion, raw; and playdough for ginger, raw)
- Groundnut sauce prepared (after cooking) using raw rice as the PSEM
- Groundnut sauce consumed by the respondent using calibrated household utensils as the PSEM

Data processing after data collection for the survey

Step 1: The following amounts are calculated using PSEM conversion factors:

- The amount of each ingredient used; this requires the use of ingredient-specific PSEM conversion factors (*shown in rows 2-5 in the table below*)
- The total amount of groundnut sauce prepared; this requires the use of a PSEM conversion factor for the mixed dish (*shown in row 6 in the table below*)
- The amount of groundnut sauce consumed by the respondent; this requires the use of a PSEM conversion factor for the mixed dish (*shown in teal in row 7 in the table below*)

The PSEM-specific factor for the mixed dish was not compiled in advance of the survey because the recipe was unknown to the survey planning team at that time. In this example, to obtain the PSEM-specific factor for the mixed dish, the density of the cooked mixed dish is derived after data collection for the survey is completed. This work is done by the survey planning team. They cook the mixed dish reported, according to the specific recipe details provided by the respondent and/or the cook during the 24-hour dietary recall interview, and record the density data for the cooked mixed dish after having prepared the mixed dish. The density data for the cooked mixed dish is then used to calculate the PSEM conversion factor with the use of raw rice as the PSEM for estimating the amount of ground sauce prepared and with the use of calibrated household utensils as the PSEM for estimating the amount of ground sauce consumed (*shown in cells highlighted in teal in the table below*).

		PSEM	Data collected using a PSEM	PSEM conversion factor		Calculated amount
				PSEM-specific factor	Edible portion factor	
Amount of each ingredient used to prepare the groundnut sauce[A]	Groundnuts, raw	Raw rice	512 g	0.76	1	389 g
	Chopped tomato, raw	Raw rice	145 g	0.48	0.85	59 g
	Onion, raw	Full-size food photograph	Photo C	85	0.85	72 g
	Ginger, raw	Playdough	12 g	0.81	1	10 g
Amount of groundnut sauce prepared		Raw rice	1,654 g	0.49[B]	1[C]	810 g
Amount of groundnut sauce consumed by the respondent		Calibrated household utensils	2 ladles	40[B]	1[C]	80 g

[A] Although this recipe is prepared with water, the amount of water used as an ingredient is not estimated.

[B] The PSEM-specific factor for a prepared mixed dish without a standard recipe cannot be derived until after the collection of 24-hour dietary recall data.

[C] Because inedible portions of mixed dishes are accounted for at the ingredient level during recipe calculations, the edible portion factor for the mixed dish is always set to 1.

Step 2: An ingredient proportion (gram to gram ratio) is calculated for each ingredient by dividing the weight of the ingredient in the form in which it was added to the mixed dish (raw in this example) by the total amount of mixed dish prepared (*shown in the second column in the table below*).

Step 3: The amount of each ingredient consumed is calculated by multiplying the amount of groundnut sauce consumed with the ingredient proportion (gram to gram ratio) for that specific ingredient (*shown in the third column in the table below*).

Ingredient[A]	Calculated ingredient proportion (gram to gram ratio)[B]	Calculated amount of ingredients consumed
Groundnuts, raw	389 ÷ 810 = 0.480	80 x 0.480 = 38 g
Chopped tomato, raw	59 ÷ 810 = 0.073	80 x 0.073 = 6 g
Onion, raw	72 ÷ 810 = 0.089	80 x 0.089 = 7 g
Ginger, raw	10 ÷ 810 = 0.012	80 x 0.012 = 1 g

[A] Although this recipe is prepared with water, the amount of water is not estimated.

[B] Ingredient proportions (gram to grams ratio) are calculated by dividing the weight of the ingredient in the form in which it was added to the mixed dish (raw in this example) by the weight of the total amount of mixed dish prepared. Note that these proportions do not add up to 1 because water as an ingredient and water loss during cooking is not accounted for.

Scenario B (recommended): The same PSEM is used to estimate the amount of mixed dish prepared and the amount of mixed dish consumed by the respondent

Data collected during the 24-hour dietary recall interview

The respondent and/or the cook are asked to estimate the amount of:

- Each ingredient used to prepare the groundnut sauce (in the form added to the mixed dish) using various PSEMs (raw rice for groundnuts; raw rice for chopped tomato, raw; full-size food photograph for onion, raw; and playdough for ginger, raw)
- Groundnut sauce prepared (after cooking) using raw rice as the PSEM
- Groundnut sauce consumed by the respondent using raw rice as the PSEM

Data processing after data collection for the survey

Step 1: The amount of each ingredient used is calculated. This requires the use of ingredient specific PSEM conversion factors (*shown in rows 2-5*). The total amount of groundnut sauce prepared and the amount of groundnut sauce consumed by the respondent are not calculated (*shown in rows 6-7*). The need for a PSEM-specific factor for the mixed dish to calculate the total amount of groundnut sauce prepared and the total amount of groundnut sauce prepared is bypassed (*shown in the cells highlighted **gray** in the table below*).

		PSEM	Data collected using a PSEM	PSEM conversion factor		Calculated amount
				PSEM-specific factor	Edible portion factor	
Amount of each ingredient used to prepare the groundnut sauce[A]	Groundnuts, raw	Raw rice	512 g	0.76	1	389 g
	Chopped tomato, raw	Raw rice	145 g	0.48	0.85	59 g
	Onion, raw	Full-size food photograph	Photo C	85	0.85	72 g
	Ginger, raw	Playdough	12 g	0.81	1	10 g
Amount of groundnut sauce prepared		Raw rice	1,020 g			
Amount of groundnut sauce consumed		Raw rice	100 g			

[A] Although this recipe is prepared with water, the amount of water used as an ingredient is not estimated.

Step 2: An ingredient proportion (gram to PSEM ratio) is calculated for each ingredient by dividing the weight of the ingredient in the form in which it was added to the mixed dish (raw in this example) by the amount of mixed dish prepared estimated using a PSEM (e.g., grams of raw rice) (*shown in the second column in the table below*).

Step 3: The amount of each ingredient consumed is calculated by multiplying the amount of groundnut sauce consumed estimated using a PSEM (e.g., grams of raw rice) with the ingredient proportion (gram to PSEM ratio) for that specific ingredient (*shown in the third column in the table below*).

Ingredient [A]	Calculated ingredient proportion (gram to PSEM ratio)	Calculated amount of ingredients consumed
Groundnuts, raw	389 ÷ 1,020 = 0.381	100 x 0.381 = 38 g
Chopped tomato, raw	59 ÷ 1,020 = 0.058	100 x 0.058 = 6 g
Onion, raw	72 ÷ 1,020 = 0.071	100 x 0.071 = 7 g
Ginger, raw	10 ÷ 1,020 = 0.010	100 x 0.010 = 1 g

[A] Although this recipe is prepared with water, the amount of water is not estimated.

[B] Ingredient proportions (gram to PSEM ratio) are calculated by dividing the weight of the ingredient in the form in which it was added to the mixed dish (raw in this example) by the weight of the amount of mixed dish prepared estimated using a PSEM. Note that these proportions do not add up to 1 because water as an ingredient and water loss during cooking is not accounted for.

3.2 PSEM-Specific Factors for Homogenous vs Non-Homogenous Mixed Dishes

A further consideration for the compilation of PSEM-specific factors for mixed dishes is the distinction between homogenous and non-homogenous mixed dishes.

- In **homogenous mixed dishes**, the ingredients are more or less evenly distributed, such that any serving from that mixed dish would contain similar proportions of the constituent ingredients.
- In **non-homogenous mixed dishes**, the ingredients are not evenly distributed in the mixture (e.g., the mixed dish has chunks of red meat, fish, or poultry in a stew).

Non-homogenous mixed dishes with a standard recipe

For non-homogenous mixed dishes with a standard recipe, survey planners can instruct enumerators either to estimate the amount of the mixed dish without disaggregating it into components or to estimate the amount of nutrient-dense ingredients separately from the amount consumed of the homogenous part of the mixed dish).

If a non-homogenous mixed dish is disaggregated for the estimation of the amount consumed, a PSEM-specific factor is needed for each nutrient-dense ingredient (e.g., chunks of fish or meat) as well as for the remaining mixture (e.g., broth, sauce, rice mixture).

In a comprehensive PSEM conversion factor database, the PSEM-specific factors for nutrient-dense ingredients are typically already available, but the PSEM-specific factor for the remaining homogenous mixture will need to be derived. Typically, this is done before data collection for the survey during standard recipe data collection.

If a non-homogenous mixed dish with a standard recipe is not disaggregated for the estimation of the amount consumed, the dish is treated as if it were a homogenous mixed dish with a standard recipe and a single PSEM-specific factor can be used for the mixed dish. When this is done, the assumption made is that any serving from that mixed dish would contain similar proportions of the constituent ingredients; often this is not true but the error is accepted.

Non-homogenous mixed dishes without a standard recipe

When a standard recipe is not available for the remaining mixture of a non-homogenous mixed dish, *Intake* does not recommend estimating the amount of the nutrient-dense ingredients separately from the amount of the homogenous part of the mixed dish). This is because when non-standard recipe data is collected during the 24-hour dietary recall survey, the respondent may not be able to estimate the total amount prepared for each separate component of the mixed dish. Furthermore, the density of the remaining mixture, which is what is needed to calculate the PSEM-specific factor, cannot be derived until after data collection for the survey is completed. This is because the recipe of a non-standard recipe is not known until the time of data collection with the respondent. Because of these complexities, *Intake* recommends prioritizing the development of standard recipes for non-homogenous mixed dishes that are likely to be frequently encountered during the survey for which there is a desire to separate the amount consumed according to the different components of the mixed dish.

A non-homogenous mixed dish without a standard recipe that is not disaggregated for the estimation of the amount consumed is treated as if it were a homogenous mixed dish without a standard recipe. Since recipe information is collected during the 24-hour dietary recall interview, a PSEM-specific factor is required for every ingredient used to prepare the mixed dish, but the use of PSEM-specific factors for the mixed dish is bypassed when the same PSEM is used to estimate the amount of total mixed dish prepared and the amount of the mixed dish consumed.

3.3 Edible Portion Factors for Mixed Dishes

Mixed dishes can include inedible parts when the mixed dish is served (e.g., meat with bones in a meat stew, shells of seafood in seafood pasta). For such mixed dishes, it may be easier for the respondent to estimate the amount of the mixed dish consumed including these inedible parts. When this is done, the only PSEMs that are suitable for estimating the amount of the mixed dish consumed are standard unit size, proxy weight using a material that can be shaped (e.g., playdough), proxy weight using a free-flowing material that is pourable (e.g., raw rice), and 3D food models (see Table 5).

Inedible portions of mixed dishes are accounted for at the ingredient level during recipe calculations, not at the recipe level. For example, for a chicken stew served with chicken including bones, an edible portion factor is applied for the chicken only. For non-homogenous mixed dishes estimated as separate components, it is typically the nutrient-dense ingredients (e.g., chunks of fish or meat) that may include an inedible portion; the remaining homogenous mixture typically does not.

In the PSEM conversion database, each ingredient used in the preparation of the mixed dish should include a corresponding edible portion factor according to whether that ingredient included inedible parts or not when added to the mixed dish, but the edible portion factor for the mixed dish is always set to 1.

3.4 Data Processing of Mixed Dishes Using PSEM Conversion Factors

During data processing, a PSEM conversion factor is needed to convert the amount of a mixed dish consumed estimated during the quantitative 24-hour dietary recall survey using a PSEM (e.g., the weight of proxy material) into the gram amount of mixed dish consumed. Recipe calculations are then applied to derive the ingredient amounts consumed.[15]

The PSEM conversion factor for a mixed dish is calculated by multiplying the PSEM-specific factor by the edible portion factor. These calculations are the same as for foods (see Table 3 in Section 2.3). However, given that inedible parts included in the mixed dish are accounted for at the ingredient level, the edible portion factor for a mixed dish is always set to 1.

Key concepts related to the use of PSEM conversion factors for the processing of homogenous and non-homogenous mixed dishes with or without a standard recipe are summarized in Table 6.

Supplementary File 1 provides example calculations for converting the portion size data reported by a respondent for a given mixed dish estimated using a pre-determined PSEM, into grams of edible ingredient consumed.

[15] For detailed guidance on the collection and analysis of recipe data in dietary surveys, *see* Vossenaar M, Hotz C, Lubowa A, Deitchler M, Moursi M, Arsenault J, Colaiezzi B, and Arimond M. 2022. *Guidance for the Use of Standard and Non-Standard Recipes in Quantitative 24-Hour Dietary Recall Surveys: The Simple Ingredient Method.* Washington, DC: *Intake* – Center for Dietary Assessment/FHI Solutions. Available at Intake.org.

Table 5. Recommended PSEMs for Homogenous and Non-Homogenous Standard and Non-Standard Recipes

<table>
<tr><th rowspan="3"></th><th colspan="3">Standard Recipe[A]</th><th colspan="3">Non-Standard Recipe[B]</th></tr>
<tr><th>Homogenous Mixed Dish[C]</th><th colspan="2">Non-Homogenous Mixed Dish[D]</th><th>Homogenous Mixed Dish[C]</th><th colspan="2">Non-Homogenous Mixed Dish[D]</th></tr>
<tr><th>Mixed dish estimated as a whole</th><th colspan="2">Mixed dish estimated as separate components</th><th>Mixed dish estimated as a whole</th><th colspan="2">Mixed dish estimated as separate components</th></tr>
<tr><td>Recommended PSEMs when the mixed dish does <u>not</u> include inedible parts (e.g., bones, shells)[E]</td><td>Amount of mixed dish consumed: All Group I and Group II PSEMs, except for full-size food photographs.</td><td>All Group I and Group II PSEMs</td><td>Playdough, raw rice, kinetic sand and calibrated household utensils</td><td>Amount of ingredients used: All Group I and Group II PSEMs.

Amount of the mixed dish prepared and consumed: Playdough and raw rice.[F]</td><td colspan="2" rowspan="2">Not recommended because the respondent may not be able to estimate the amount prepared of each separate component (e.g., the amount of pieces of fish and the amount of the remaining mixture).</td></tr>
<tr><td>Recommended PSEMs when the mixed dish includes inedible parts (e.g., bones, shells)</td><td>Amount of mixed dish consumed: Standard unit size, playdough, raw rice and 3D food models</td><td>Standard unit size, playdough, raw rice, full-size food photograph, 3D food models</td><td>Not applicable[G]</td><td>Amount of ingredients used: Standard unit size, playdough, raw rice, full-size food photograph, 3D food models.

Amount of the mixed dish prepared: Playdough and raw rice.[F]

Amount of mixed dish consumed: Playdough and raw rice.[F]</td></tr>
</table>

A Standard recipes aim to reflect the way that mixed dishes are usually prepared by respondents and are often developed in advance of data collection for mixed dishes that are commonly consumed by members of the target population for the survey.

B When a standard recipe is <u>not</u> available for a mixed dish reported, the enumerator must collect detailed information about the preparation of that mixed dish during the 24-hour dietary recall interview to derive a "non-standard recipe."

C In homogenous mixed dishes, the ingredients are more or less evenly distributed, such that any serving from that mixed dish would contain similar proportions of the constituent ingredients.

D In non-homogenous mixed dishes, the ingredients are not evenly distributed in the mixture (e.g., chunks of red meat, fish, or poultry in a stew).

E For an overview of the suitability of PSEMs for mixed dishes, see Table 2 in Vossenaar M, Lubowa A, Hotz C, Deitchler M, Moursi M, Arimond M, Crispim SP, and Arsenault J. 2020. *Considerations for the Selection of Portion Size Estimation Methods for Use in Quantitative 24-Hour Dietary Recall Surveys in Low- and Middle-Income Countries.* Washington, DC: *Intake* – Center for Dietary Assessment/FHI Solutions. Available at: Intake.org..

F *Intake* recommends using the same PSEM to estimate the amount of total mixed dish prepared and the amount of the mixed dish consumed. When this is done, the need to derive a PSEM-specific factor for the mixed dish is bypassed.

G A remaining mixture of a non-homogenous mixed dish should not include inedible portions.

Table 6. PSEM Conversion Factors for Homogenous and Non-Homogenous Standard and Non-Standard Recipes

	Standard Recipe[A]			Non-Standard Recipe[B]	
	Homogenous Mixed Dish[C]	Non-Homogenous Mixed Dish[D]		Homogenous Mixed Dish[C]	Non-Homogenous Mixed Dish[D]
	Mixed dish estimated as a whole	Mixed dish estimated as separate components		Mixed dish estimated as a whole	Mixed dish estimated as separate components
		Nutrient-dense ingredients	Remaining mixture		
Required PSEM-specific factors	A PSEM-specific factor for the mixed dish.	A PSEM-specific factor for each nutrient-dense ingredient	A PSEM-specific factor for the remaining mixture	*Amount of ingredients used*: A PSEM-specific factor for each ingredient. *Amount of the mixed dish prepared and consumed:* The need for a PSEM-specific factor for the mixed dish is bypassed when the same PSEM is used to estimate the amount of total mixed dish prepared and the amount of the mixed dish consumed.[F]	Not applicable[G]
Required edible portion factors	Any inedible parts included in the mixed dish are accounted for at the ingredient level during the recipe calculation.	An edible portion factor for each nutrient-dense ingredient	The remaining mixture should not include inedible parts (the edible portion factor is set to 1).	*Amount of ingredients used*: An edible portion factor for each ingredient. *Amount of the mixed dish prepared and consumed:* Any inedible parts included in the mixed dish are accounted for at the ingredient level during the recipe calculation.[F]	Not applicable[G]

A Standard recipes aim to reflect the way that mixed dishes are usually prepared by respondents and are often developed in advance of data collection for mixed dishes that are commonly consumed by members of the target population for the survey.

B When a standard recipe is not available for a mixed dish reported, the enumerator must collect detailed information about the preparation of that mixed dish during the 24-hour dietary recall interview to derive a "non-standard recipe."

C In homogenous mixed dishes, the ingredients are more or less evenly distributed, such that any serving from that mixed dish would contain similar proportions of the constituent ingredients.

D In non-homogenous mixed dishes, the ingredients are not evenly distributed in the mixture (e.g., chunks of red meat, fish, or poultry in a stew).

F *Intake* recommends using the same PSEM to estimate the amount of total mixed dish prepared and the amount of the mixed dish consumed. When this is done, the need to derive a PSEM-specific factor for the mixed dish is bypassed.

G When a standard recipe is not available for the remaining mixture of a non-homogenous dish, Intake does not recommend estimating components separately.

3.5 Additional Conversions Required for Mixed Dish Substitutions

When collecting quantitative 24-hour dietary recall data, the use of substitutions is most commonly applied to foods as opposed to mixed dishes. However, in some contexts, survey planners may also decide to allow substitutions for the estimation of mixed dishes. When substitutions are allowed for the estimation of mixed dishes, the PSEM developed for a given mixed dish is used for a similar mixed dish. As described earlier, the only PSEMs for which substitutions are relevant to consider are direct weight and graduated portion-size food photographs.

The use of substitutions should only be considered for the following types of mixed dishes:

- Mixed dishes for which a standard recipe has been developed
- Mixed dishes for which the actual mixed dish and the substitution mixed dish are homogenous
- Mixed dishes for which the actual mixed dish and the substitution mixed dish have the same core ingredients (e.g., maize flour in maize porridge).[16] Supplementary ingredients[17] included in the actual mixed dish and in the substitution mixed dish may vary (e.g., sugar).

When substitutions for mixed dishes are allowed, an additional conversion factor (referred to as the "substitution factor") is required to translate the portion size represented by the food replica or in the graduated portion-size food photograph into the portion size of the substitution mixed dish (i.e., the actual mixed dish reported as consumed).

When using substitutions with mixed dishes, the following data are needed to derive the substitution factor:

- The density of the substitution mixed dish
- The density of the food replica (applies when direct weight is used as the PSEM for the mixed dish)
- The density of the mixed dish depicted in the food photograph (applies when graduated portion-size food photographs are used as the PSEM for the mixed dish)

Table 6 provides an overview of the calculations relevant to the use of substitutions with homogenous mixed dishes for which a standard recipe has been developed.

[16] Core ingredients are primary constituent ingredients of a mixed dish. Core ingredients make a significant nutritional contribution to the mixed dish and are often included in the name of the mixed dish and should be included in the name of the standard recipe.

[17] Supplementary ingredients have a significant nutritional contribution to the mixed dish and may or may not be included in a given standard recipe without changing the basic nature of the dish. Their use in a given mixed dish depends on the availability of the ingredients and personal preferences.

Table 7. Calculations to Determine the Gram Weight of Edible Ingredient Consumed When Allowing Substitutions, by PSEM

PSEM	Data recorded during 24-hour recall	PSEM Conversion Factor (calculated by multiplying the "PSEM-specific factor" by the "edible portion factor")		Substitution factor	Calculation to determine grams of edible ingredient consumed
		PSEM-specific factor	Edible portion factor		
Group I PSEMs: Methods that do not require extensive preparatory work in advance of the survey					
1. **Direct weight** using food replicas	Weight (g) of food replica	The PSEM-specific factor is set to 1	The edible portion factor is set to 1[A]	Density of the substitution mixed dish (g/ml) ÷ density of the food replica (g/ml)	PSEM conversion factor × weight of food replica × substitution factor
Group II PSEMs*:* Methods that require extensive preparatory work in advance of the survey					
7. **Graduated portion-size food photographs** depicting multiple portion sizes for a given mixed dish	Photograph code and, if relevant, number and/or fraction of units consumed[B]	Grams of the portion size depicted	The edible portion factor is set to 1[A]	Density of the substitution mixed dish (g/ml) ÷ density of the mixed dish depicted (g/ml)	PSEM conversion factor (× number and/or fraction of units consumed) × substitution factor

[A] Mixed dishes estimated using this PSEM should not include any inedible parts.

[B] If allowed after careful consideration.

4 Compiling a PSEM Conversion Factor Database for the Survey

The PSEM conversion factor database should ideally be compiled to the fullest extent possible before beginning data collection for the survey. There are several advantages to preparing the PSEM conversion factor database before data collection for the survey. These include: preventing potentially long delays between the time the data are collected and when the data are ready to be analyzed, ensuring that all data required for the PSEM conversion factor database can be obtained, and helping foresee difficulties that may warrant the assignment of a different PSEM to a food or mixed dish. When using electronic data collection, a further advantage of compiling a complete PSEM conversion factor database before data collection is that, depending on the software application, it may be possible to undertake some aspects of data processing during data collection, thereby allowing for more detailed data quality checks in the field.

In this section, we describe how to compile the data needed for the PSEM conversion factor database. We first describe how to compile the PSEM conversion factor data needed to convert amounts of foods and ingredients into the gram weight of the edible portion of the food item consumed (Section 4.1). Then we describe how to compile the PSEM conversion factor data needed to convert amounts of mixed dishes into the gram weight of the edible portion of each ingredient consumed in the mixed dish (Section 4.2).

4.1 Compiling PSEM Conversion Factor Data for Foods

Once PSEMs have been assigned for all foods listed in the FRIL and a list of the needed PSEM-specific factors and edible portion factors has been compiled, potential sources for obtaining the needed data should be explored. Most of the data required for the compilation of a PSEM conversion factor database require primary data collection in the environment where the survey will be carried out (as indicated by the cells shaded in teal in Table 8). However, for some data, such as food density and edible portion factors, it may be possible to rely on existing data sources for some foods in the FRIL (see cells shaded in turquoise in Table 8).

When survey circumstances allow, the collection of primary data over the use of secondary data is recommended for the development of PSEM conversion factors. In situations where survey resources are limited and do not allow for only primary data to be used, primary data collection should be prioritized for those foods that are widely consumed and are likely to contribute a significant proportion of energy or nutrient intakes for the survey population.

Key considerations and tradeoffs related to the collection of primary data versus the use of secondary data sources when compiling data for a PSEM conversion factor database are described in Table 9.

Table 8. Data Sources to Compile the PSEM Conversion Factors for Foods, by PSEM[A]

PSEM	PSEM conversion factor (calculated by multiplying the PSEM-specific factor by the edible portion factor)			
	PSEM-specific factor			Edible portion factor
Group I PSEMs: Methods that do not require extensive preparatory work in advance of the survey				
1. **Direct weight** using food replicas	The PSEM-specific factor is set to 1			The edible portion factor is set to 1[B]
2. **Standard unit size** (each unit corresponds to a known weight)	Grams per standard unit[C]			Edible portion factor[D]
3. **Proxy weight using materials that can be shaped** (e.g., playdough) — *Preferred approach*[E]	Density of the food	÷	Density of the proxy material	Edible portion factor
3. **Proxy weight using materials that can be shaped** (e.g., playdough) — *Alternative approach*[F]	Weight of the food	÷	Weight of the same volume of the proxy material	Edible portion factor[D]
4. **Proxy weight using free-flowing materials** that are pourable (e.g., raw rice)	Density of the food	÷	Density of the proxy material	Edible portion factor
5. **Proxy weight using materials that heap** (e.g., Kinetic Sand®)	Density of the food	÷	Density of the proxy material	The edible portion factor is set to 1[B]
6. **Calibrated household utensils** (e.g., spoons, scoops, ladles)	Volume of utensil[G]	x	Density of the food	The edible portion factor is set to 1[B]
Group II PSEMs: Methods that require extensive preparatory work in advance of the survey				
7. **Graduated portion-size food photographs** depicting multiple portion sizes for a given food	Grams of the portion size depicted[H]			The edible portion factor is set to 1[B]
8. **Full-size food photographs** depicting multiple unit sizes of a food in a whole, unprocessed state	Grams of the unit size depicted[H]			Edible portion factor[D]
9. **2D shapes** depicting multiple unit sizes for a given food	Grams of the unit size depicted[H]			The edible portion factor is set to 1[B]
10. **3D food models** depicting multiple unit sizes for a given food	Grams of the unit size depicted[H]			Edible portion factor[D]

[A] Cells shaded in teal (e.g., *grams per standard unit*) represent data that require primary data collection, cells shaded in turquoise (e.g., *density of the food*) represent data that could be derived from existing data sources, and cells shaded in gray (e.g., *the PSEM-specific factor is set to 1*) represent data that do not need to be compiled.

[B] Food items estimated using this PSEM should not include any inedible parts.

[C] Measuring the weight of food items is not required when it is a commercial product of known weight, e.g., indicated on the packaging.

[D] Since primary data collection is needed to derive the PSEM-specific factor, which provides an opportunity to also derive edible portion factors at the same time, primary data collection is recommended to derive the edible portion factor.

[E] The preferred approach is recommended to derive the PSEM-specific factor when accurate density data for the reported food can be obtained.

[F] The alternative approach can be used to derive the PSEM-specific factor when it is not feasible to obtain accurate density data for the reported food.

[G] The density of water is 1. Therefore, the volume of the spoon is equal to the weight of the water, when the spoon is filled with water.

[H] When using existing food photographs, 2D shapes, or 3D food models developed for previous dietary surveys, primary data should not be collected. The documented gram weights for the existing photos, shapes, or models should be used, with careful consideration given to whether these weights correspond to the whole food or only the edible portion.

Table 9. Considerations Related to the Collection of Primary Data vs. the Use of Existing Data Sources to Fill Gaps in a PSEM Conversion Factor Database

	Primary data collection	Existing data sources
Availability of the data	Can be time-consuming and requires careful planning.	Existing data are typically available only for food density and edible portion factor and only for a relatively limited set of foods.
	Allows for data collection of all foods in the specific form, state, and presentation mode, included in the survey-specific FRIL.	Data sources are unlikely to list foods in all the forms (e.g., mashed/pureed, finely diced, coarsely chopped), physical states (e.g., cooked, grilled, raw), and presentation modes (e.g., served with or without inedible parts) relevant to the survey.
Context specificity	Allows for context-specific data collection (i.e., that accounts for any country-specific variations in food density and edible portion factors).	Data are often compiled for a different country and even a different region in the world. Therefore, data may not be available for local varieties of foods and indigenous foods. Databases from previously conducted dietary surveys are more likely to be local than national surveys, and therefore more relevant to the local context, but oftentimes such local databases are not available.
Data quality	Survey staff can ensure rigorous, standardized data collection procedures. All procedures used and decisions made can (and must) be well documented.	It may be difficult to make a judgment on the quality of the data. For any given food, there may be different values reported across various data sources, making it difficult to make a well-informed decision about which value to use and possibly bringing into question the reliability of the data. Values for a given food may have been borrowed from a similar food, and this may or may not be documented in the existing data source.
Ease of use	The data files can be set up according to survey needs.	Existing data sources are often not straightforward to use and require a correct understanding of the data to ensure correct use. To use the data provided in some resources may require making calculations to derive the values required for use in a PSEM conversion factor database (e.g., density for a food may need to be derived from the reported volume and weight data recorded for the food).

4.1.1 Guidance on Primary Data Collection for PSEM-Specific Factors for Foods

As shown in Table 7, all PSEM-specific factors for Group I and Group II PSEMs, except direct weight, require some primary data collection. Primary data collected to derive PSEM-specific factors should be collected systematically using standardized procedures. An overview of the primary data required to obtain the data needed to derive the PSEM-specific factors for foods is provided below for each Group I and Group II PSEM. In addition, detailed step-by-step procedures are provided in Annex 1 for Group I PSEMs.[18]

DIRECT WEIGHT

Direct weight does not require the use of a PSEM-specific factor because the amount of food replica representing the food consumed is weighed directly in grams. As a result, the PSEM-specific factor is set to 1.

STANDARD UNIT SIZE

The use of standard unit size as a PSEM requires primary data collection to determine the corresponding gram weight of the standard unit size (refer to Annex 1, Box 5 for the recommended procedure). The standard unit weight for a given unit size should represent the average weight of several units of the same food. The weight obtained for the standard unit should be the weight of the food in the form in which it is visualized during portion size estimation (e.g., including inedible parts, such as bones, seeds, pits, or peels, that are typically removed during eating). Measuring the weight of foods is not required when it is a commercial product for which the unit size is established and documented on the packaging (e.g., a can of soda).

PROXY WEIGHT

With the use of proxy weight as a PSEM, two different approaches can be used to derive the PSEM-specific factor. Each approach has different data requirements. Figure 1 provides a flowchart to aid the selection of which PSEM-specific factor approach and food density method to use when using proxy weight as a PSEM.

The Preferred Approach

The "preferred approach" to derive the PSEM-specific factor for a given food requires obtaining accurate density data for both the proxy material used during the 24-hour dietary recall interview and the food reported as consumed.

Deriving density data for proxy materials always require primary data collection (refer to Annex 1, Box 6. for the recommended procedure). An accurate density value for the proxy material is needed because this value is used for the conversion of all foods for which amounts are estimated using the proxy material during the survey. Furthermore, to ensure accurate conversion into the equivalent weight of foods, the density of a proxy material must remain consistent throughout a survey. When using playdough, which is prone to drying or absorbing moisture, field staff should monitor its density regularly (e.g., at the start of the survey and at least once a week thereafter). A simple log sheet can be used to track the density of the playdough. If the calculated density changes by more than 10% (which usually corresponds to ±0.1 g/ml) from the beginning of the survey, it should be replaced with unused playdough of the same type and from the same manufacturer (see guidance for the monitoring of playdough density in Annex 2). The density of raw rice and Kinetic Sand® should be relatively stable unless there are large fluctuations in humidity throughout the survey.

Because of the variability that is possible in the level of packing of Kinetic Sand®, *Intake* recommends only using Kinetic Sand® for scooping and heaping and not for any molding of shapes. Therefore the measuring cup used to determine its density should be filled loosely to avoid 'overpacking' (this would result in a substantially higher density than when the respondent is scooping). In addition, Kinetic Sand® should always be stored and transported (including during data collection) in solid containers (not plastic bags) to avoid compression. When

[18] Procedures for primary data collection to derive PSEM-specific factors for Group II PSEMs are not provided in this document because the weight for each portion or unit size depicted in the food photograph, 2D shape, or 3D food model series (i.e., the PSEM-specific factor) is established at the time of photo, shape, or model development.

using raw rice, a single brand, source, and type of rice should be used by all enumerators across all survey teams, as the density can vary depending on grain size.

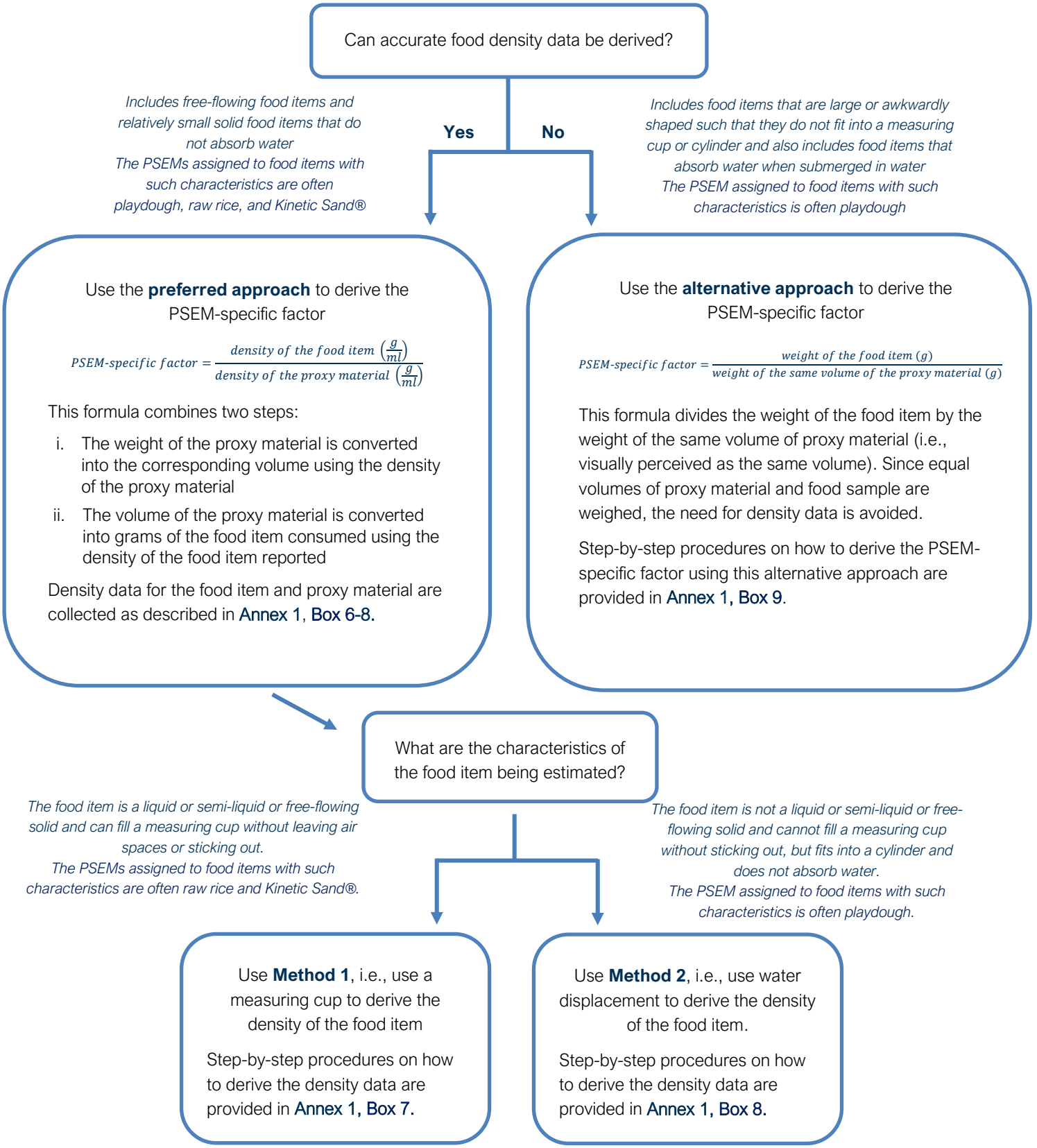
Density data are also needed for each food for which amounts consumed are being estimated. When primary data collection is used to collect food density data, two different methods can be considered for deriving the density of the food. The choice of which method to use depends on the characteristics of the food. For any given survey, both methods would likely be used, but only one method should be used for any one specific food.

- **Method 1** (using a measuring cup) is well suited for foods that can fit into a measuring cup, i.e., foods that are liquid or semi-liquid or free-flowing solids. Foods that have been assigned a proxy material that is free-flowing or that heaps as the PSEM (e.g., raw rice, Kinetic Sand®) generally have these characteristics. Examples of free-flowing foods include soups and rice dishes. Refer to Annex 1, Box 7. for the recommended procedure.
- **Method 2** (using water displacement) is well suited for foods that cannot fit into a measuring cup and that do not absorb water, i.e., foods that are large or awkwardly shaped but still fit in a graduated cylinder and do not absorb water. Foods that are assigned a proxy material that can be shaped as the PSEM (e.g., playdough) sometimes have characteristics that preclude the collection of density data using Method 1. Examples include pieces of fruit or meat. Refer to Annex 1, Box 8. for the recommended procedure.

The Alternative Approach

When it is not feasible to obtain accurate data on food density using either method described above, an alternative approach can be used to derive the PSEM-specific factor for that food. This alternative approach can be used with foods that have specific characteristics, i.e., large or awkwardly shaped foods that may not fit into a measuring cup or graduated cylinder, and absorb water, and can therefore not be submerged in water (e.g., bread). This alternative approach requires primary data collection that entails weighing visually equal volumes of proxy material and foods and calculating the PSEM-specific factor based on the respective weights (refer to Annex 1, Box 9. for recommended procedures).

Figure 1. Flowchart to Guide the PSEM-Specific Factor Approach and Density Data Collection Method (if relevant) to Use for Foods Estimated Using Proxy Weight



CALIBRATED HOUSEHOLD UTENSILS

The use of calibrated household utensils as a PSEM requires primary data collection to determine the volume of each household utensil that will be used as a PSEM (refer to Annex 1, Box 10. for the recommended procedure).

In addition, the density of all the foods estimated using this PSEM is needed. Because this PSEM is assigned to homogenous foods that are free-flowing and do not heap (e.g., liquid foods such as oils, thin sauces), when collecting food density data for foods for which calibrated household utensils have been assigned as the PSEM, the density of the foods can be estimated using a measuring cup. This method for deriving density data is referred to as Method 1 (refer to Annex 1, Box 7. for the recommended procedure).

FOOD PHOTOGRAPHS, 2D SHAPES, AND 3D FOOD MODELS

With the use of Group II PSEMs (i.e., graduated portion-size and full-size food photographs, 2D shapes, and 3D food models), the weight for each portion or unit size depicted in the food photograph, 2D shape, or 3D food model series (i.e., the PSEM-specific factor) is established at the time of photo,[19] shape, or model development.[20] The weight assigned to each photograph, 2D shape, or 3D food model should represent the food in the form in which it is visualized (e.g., including inedible parts, such as bones, seeds, pits, or peels, that may be removed before eating).

4.1.2. Guidance for Primary Data Collection of Edible Portion Factors for Foods

When the decision is made to collect primary data to derive the edible portion factors for foods, data should be collected systematically using standardized procedures for the specific survey. A detailed step-by-step procedure for primary data collection of edible portion factors is provided in Annex 3, Box 13.

Edible portion factors can vary by size, breed, or variety (e.g., the proportions of bone or seeds relative to the proportion of flesh can vary between different livestock breeds or fruit or vegetable varieties). Where the difference between sizes of a given food is very large, it may be necessary to derive separate edible portion factors for different size categories to avoid introducing unnecessary error, particularly if the food is commonly consumed (e.g., "small" or "large" bananas). Similarly, it may be necessary to derive separate edible portion factors for different breeds or varieties of a given food. However, doing so has implications for the FRIL developed for the survey, as each option (i.e., size, breed, variety of the food) needs to be listed in the FRIL separately, and relevant probes for use during the interview need to be elaborated on to ensure that the correct size, breed, and/or variety of the food consumed can be identified during data collection.

4.1.3. Guidance on the Use of Existing Data Sources for Food Density and Edible Portion Factors

Although most PSEM conversion factors require some primary data collection,[21] in some contexts it may be possible to rely on existing data sources for food density and edible portion factor data (Table 8).

Potential data sources for food density and edible portion factors include published resources and previously conducted dietary surveys (for both small- and large-scale dietary surveys). Some recommended sources for obtaining published data on edible portion factors and food density data are listed in Annex 4 and can be downloaded from the *Intake* online resource library, available at Intake.org.

Existing data resources are very unlikely to provide food density data and edible portion factors for all foods, beverages, and ingredients listed in a FRIL developed for a survey. Furthermore, local data may be needed whenever edible portion factors vary by size, breed, or variety of a given food. Nevertheless, the use of existing data sources for those foods for which density and edible portion data are readily available can

[19] For detailed guidance on the development of food photographs, see Vossenaar M, Crispim SP, Lubowa A, Deitchler M, Moursi M, Arimond M. 2020. *Guidance for the Development of Food Photographs for Portion Size Estimation in Quantitative 24-Hour Dietary Recall Surveys in Low- and Middle-Income Countries*. Washington, DC and Curitaba, Brazil: *Intake* – Center for Dietary Assessment/FHI Solutions and Department of Nutrition, Federal University of Paraná. Available at Intake.org.

[20] For detailed guidance on how to select unit sizes to reflect in 2D shapes and 3D food models, refer to Annex 1 in Vossenaar M, Lubowa A, Hotz C, Deitchler M, Moursi M, Arimond M, Crispim SP, and Arsenault J. 2020. *Considerations for the Selection of Portion Size Estimation Methods for Use in Quantitative 24-Hour Dietary Recall Surveys in Low- and Middle-Income Countries.* Washington, DC: *Intake* – Center for Dietary Assessment/FHI Solutions. Available at Intake.org.

[21] The exceptions are direct weight and standard unit size for commercial products with portion sizes indicated on the package.

significantly lessen the extent of primary data collection required to compile the PSEM conversion factor database.

When using existing sources for food density data and edible portion factors, it is essential for the survey staff compiling the PSEM conversion factor data to document the source of the data and provide all available relevant details to inform how those data are meant to be used and interpreted (e.g., is the density of the food for the entire food or only the edible portion). If sufficient detail is not provided in the secondary data source to ensure the correct use and interpretation of the data, it should not be used.

4.2 Compiling PSEM Conversion Factors for Mixed Dishes

Existing data sources to compile PSEM-specific factors for mixed dishes (such as density data for a mixed dish, which are needed when using proxy materials or calibrated household utensils as the PSEM) are rarely available. As such, all data required for the compilation of PSEM-specific factors for mixed dishes will require primary data collection in the environment where the survey is to be carried out. The primary data collection requirements for the compilation of PSEM-specific factors for mixed dishes are indicated by the cells shaded in teal in Table 9.

Table 10. Data Sources to Compile the PSEM Conversion Factors for Mixed Dishes, by PSEM[A]

PSEM		PSEM conversion factor (calculated by multiplying the PSEM-specific factor by the edible portion factor)				PSEM is suitable for mixed dishes with a standard recipe		PSEM is suitable for mixed dishes with a non-standard recipe	
		PSEM-specific factor			Edible portion factor[B]	Homogenous or non-homogenous, estimated as a whole	Non-homogenous, estimated as separate components[C]	Homogenous or non-homogenous, estimated as a whole	Non-homogenous, estimated as separate components[C]
Group I PSEMs: Methods that do not require extensive preparatory work in advance of the survey									
1. **Direct weight** using food replicas		The PSEM-specific factor is set to 1			The edible portion factor is set to 1	Yes (when no inedible portions are included)	No	No	Not recommended because the respondent may not be able to estimate the amounts prepared of each separate component (e.g., the amount of pieces of fish and the amount of remaining mixture).
2. **Standard unit size** (each unit corresponds to a known weight)		Grams per standard unit			The edible portion factor is set to 1	Yes	No	No	
3. **Proxy weight using a material that can be shaped** (e.g., playdough)	*Preferred approach*[D]	Density of the mixed dish (or remaining mixture)	÷	Density of the proxy material	The edible portion factor is set to 1	Yes	Yes	Yes	
	Alternative approach[E]	Weight of the mixed dish (or remaining mixture)	÷	Weight of the same volume of the proxy material	The edible portion factor is set to 1	Yes	Yes	Yes	

[A] Cells shaded in teal represent data that require primary data collection and cells shaded in gray represent data that does not need to be compiled.

[B] Since inedible portions of mixed dishes are accounted for at the ingredient level during recipe calculations, the edible portion factor is always set to 1.

[C] Relates to the remaining mixture of non-homogenous mixed dishes.

[D] The preferred approach is recommended to derive the PSEM-specific factor when accurate density data for the reported food can be obtained.

[E] The alternative approach can be used to derive the PSEM-specific factor when it is not feasible to obtain accurate density data for the reported food.

PSEM	PSEM conversion factor (calculated by multiplying the PSEM-specific factor by the edible portion factor)			PSEM is suitable for mixed dishes with a standard recipe		PSEM is suitable for mixed dishes with a non-standard recipe	
	PSEM-specific factor		Edible portion factor[B]	Homogenous or non-homogenous, estimated as a whole	Non-homogenous, estimated as separate components[C]	Homogenous or non-homogenous, estimated as a whole	Non-homogenous, estimated as separate components[C]
4. **Proxy weight using a free-flowing material** that is pourable (e.g., raw rice)	Density of the mixed dish (or remaining mixture)	÷ Density of the proxy material	The edible portion factor is set to 1	Yes	Yes	Yes	Not recommended because the respondent may not be able to estimate the amounts prepared of each separate component (e.g., the amount of pieces of fish and the amount of remaining mixture).
5. **Proxy weight using a material that heaps** (e.g., Kinetic Sand®)[F]	Density of the mixed dish (or remaining mixture)	÷ Density of the proxy material	The edible portion factor is set to 1	Yes (when no inedible portions are included)	Yes	No[F]	
6. **Calibrated household utensils** (e.g., spoons, scoops, ladles)	Volume of utensil	÷ Density of the mixed dish (or remaining mixture)	The edible portion factor is set to 1	Yes (when no inedible portions are included)	Yes	No[F]	

[A] Cells shaded in teal represent data that require primary data collection and cells shaded in gray represent data that does not need to be compiled.

[B] Since inedible portions of mixed dishes are accounted for at the ingredient level during recipe calculations, the edible portion factor is always set to 1.

[C] Relates to the remaining mixture of non-homogenous mixed dishes.

[F] This PSEM is not suitable to estimate the total amount of mixed dish prepared because it is not suitable to estimate large amounts.

PSEM	PSEM conversion factor (calculated by multiplying the PSEM-specific factor by the edible portion factor)		PSEM is suitable for mixed dishes with a standard recipe		PSEM is suitable for mixed dishes with a non-standard recipe	
	PSEM-specific factor	Edible portion factor[B]	Homogenous or non-homogenous, estimated as a whole	Non-homogenous, estimated as separate components[C]	Homogenous or non-homogenous, estimated as a whole	Non-homogenous, estimated as separate components[C]
Group II PSEMs*:* Methods that require extensive preparatory work in advance of the survey						
7. **Graduated portion-size food photographs** depicting multiple portion sizes for a given food item	Grams of the unit size depicted	The edible portion factor is set to 1	Yes (when no inedible portions are included)	No	No	Not recommended because the respondent may not be able to estimate the amounts prepared of each separate component (e.g., the amount of pieces of fish and the amount of remaining mixture).
8. **Full-size food photographs** depicting multiple unit sizes of a food in a whole, unprocessed state	PSEM is not suitable for mixed dishes		No	No	No	
9. **2D shapes** depicting multiple unit sizes for a given food item	Grams of the unit size depicted	The edible portion factor is set to 1	Yes (when no inedible portions are included)	No	No	
10. **3D food models** depicting multiple unit sizes for a given food item	Grams of the unit size depicted	The edible portion factor is set to 1	Yes	No	No	

[A] Cells shaded in **teal** represent data that require primary data collection and cells shaded in gray represent data that does not need to be compiled.

[B] Since inedible portions of mixed dishes are accounted for at the ingredient level during recipe calculations, the edible portion factor is always set to 1.

[C] Relates to the remaining mixture of non-homogenous mixed dishes.

4.2.1 Guidance on Primary Data Collection for PSEM-Specific Factors for Mixed Dishes

An overview of the primary data collection required to obtain the data needed to derive the PSEM-specific factors for mixed dishes with and without a standard recipe is provided below. For step-by-step procedures to use for primary data collection for PSEM-specific factors for mixed dishes refer to Annex 1. The same procedures used to collect primary data for PSEM-specific factors for foods estimated with Group I PSEMs are also relevant to follow in the case of mixed dishes.[22]

MIXED DISHES WITH A STANDARD RECIPE

Group I PSEMs: Standard unit size, proxy weight, and calibrated household utensils

The development of standard recipes typically entails organizing cooking sessions with local cooks. These cooking sessions provide an opportunity to collect the data needed to derive the PSEM-specific factor for a standard recipe. The data collected to derive the PSEM-specific factor are:

- The weight of a standard unit (if standard unit size will be used as a PSEM for the mixed dish)
- The density of the mixed dish (if proxy materials or calibrated household utensils will be used as a PSEM for the mixed dish)
- The density of the remaining mixture for non-homogenous mixed dishes (for which the amount can be estimated only using proxy weight or calibrated household utensils)

For mixed dishes that are typically prepared outside the home, such as mixed dishes prepared by vendors and restaurants, it may not be possible to organize cooking sessions to collect standard recipe data. To collect standard recipe data for these mixed dishes, vendors and restaurants where the mixed dish is sold are typically visited and requested to provide the needed recipe information. In some contexts, it may be necessary to purchase the mixed dish to derive the PSEM-specific factor for a standard recipe.

For non-homogenous mixed dishes for which components are estimated separately, a PSEM-specific factor for the remaining mixture will need to be derived after data collection.

Primary data collection is generally recommended for standard recipes because of the context-specific nature of the preparation of mixed dishes, but in some specific cases, it may be appropriate to borrow standard recipe data from a previous dietary survey carried out among the same target population or geographic area. However, when borrowing standard recipe data from a previous dietary survey[23]—thus bypassing cooking sessions—it is unlikely that density data will be available for the mixed dish from that data source. Therefore, if the PSEM assigned to a mixed dish would require density data for the mixed dish to derive the PSEM-specific factor, the recipe for that mixed dish would likely need to be prepared by survey staff for the sole purpose of deriving the density data needed for that mixed dish.

Group II PSEMs: Food photographs, 2D shapes, and 3D food models

When using Group II PSEMs, the weight of the depicted amounts (i.e., grams per portion or unit size depicted) should be determined during the development of the portion-size food photographs, 2D shapes, and 3D food models.

[23] Recommended requirements for the use of existing data sources for standard recipes are provided in Annex 2 in Vossenaar M, Hotz C, Lubowa A, Deitchler M, Moursi M, Arsenault J, Colaiezzi B, and Arimond M. 2022. *Guidance for the Use of Standard and Non-Standard Recipes in Quantitative 24-Hour Dietary Recall Surveys: The Simple Ingredient Method.* Washington, DC: *Intake* – Center for Dietary Assessment/FHI Solutions. Available at Intake.org.

MIXED DISHES WITH A NON-STANDARD RECIPE

Proxy weight

For a mixed dish without a standard recipe, when the same PSEM is used to estimate the total amount of the mixed dish prepared and the amount of the mixed dish consumed by the respondent, as is recommended, the need to derive a PSEM-specific factor for the non-standard recipe is bypassed (see Box 4, Scenario B [page 20]).

However, when a different PSEM is used to estimate the amount of mixed dish consumed and the total amount of mixed dish prepared, PSEM-specific factors are needed to derive the amounts of mixed dish prepared and consumed (see Box 4, Scenario A [page 18]). Because these PSEM-specific factors cannot be derived before data collection for the survey, the mixed dishes that are reported during the survey and for which a standard recipe does not exist will need to be prepared after data collection to derive the necessary PSEM-specific factors.

4.2.2 Guidance on Data Collection for Edible Portion Factors for Mixed Dishes

When mixed dishes are served with inedible parts included, and these are included in the estimation of the amount consumed, the inedible parts will need to be accounted for during data processing. For mixed dishes, regardless of whether a standard or non-standard recipe is used, the inedible parts are accounted for at the ingredient level in the calculations used to derive the amount of each ingredient consumed by the respondent. As such, the edible portion factor for the mixed dishes is set to 1 and no primary data collection is required to account for this at the mixed dish level. An edible portion factor is, however, assigned to each ingredient in the mixed dish. The step-by-step procedure for primary data collection to derive edible portion factors for foods is also relevant to follow in the case of ingredients included in a mixed dish. The detailed step-by-step procedure to follow for primary data collection of edible portion factors is provided in Annex 3, Box 13.

5 Format of the PSEM Conversion Factors Database for the Survey

The PSEM conversion factor database for the survey is the compilation of all PSEM conversion factors needed for each food, beverage, standard recipe, and ingredient included in the FRIL developed for the survey. When more than one PSEM is assigned to a food item, a separate conversion factor is needed for each PSEM assigned. In addition, if substitutions are allowed with the use of direct weight or graduated portion-size food photographs, the PSEM conversion factors database will need to integrate these additional conversions as separate columns in the database.

Typically, PSEM conversion factors for foods (which include ingredients) and mixed dishes are listed together, but a variable is specified to indicate if the food item is a food or a mixed dish. For non-homogenous mixed dishes estimated as separate components, PSEM conversion factors for the remaining mixtures will need to be included in the database. The PSEM conversion factor database developed in advance of data collection will not include PSEM conversion factors for mixed dishes for which a standard recipe was not developed. This is because these cannot be derived until recipe details are collected during the 24-hour dietary recall interview.

During the compilation of PSEM conversion factors, often a "master" database is created in which the PSEM-specific factor, the edible portion factor, the PSEM conversion factor, and the substitution factor (if relevant) are listed in separate columns, as well as the data used to derive these factors (e.g., the volume of the calibrated household utensil and the density of the food item being estimated used to derive the PSEM-specific factor). The file should also contain detailed documentation notes on the sources of these data, and how they were derived, for future reference. Doing so ensures that all data values are well documented, both for quality checks and potential further use in other dietary surveys.

Two example templates of a "master" PSEM conversion factor database are provided in a spreadsheet format in Supplementary File 2. The first template does not allow the use of substitution, whereas the second one does (when direct weight or graduated portion-size food photographs are used as PSEM).

The PSEM conversion factors database used for data processing is typically an abbreviated version of the master database (i.e., columns not directly needed for the calculations are deleted). The format of this PSEM conversion factor database depends on the software that is used to process the dietary data and must be configured to the exact specifications of the selected software application (e.g., pre-determined variable names, columns in a specific order). Typically, each row in the database corresponds to a given food item listed in the FRIL and the assigned PSEM. Where more than one PSEM is used for a food item in the FRIL, the PSEM conversion factor associated with each PSEM will appear on a separate line. Also, for PSEMs that require more than one PSEM-specific factor, such as different photograph sizes, each of these options is coded and labeled and the associated PSEM conversion factor is given on a separate line. Depending on the software used, the database may not include a column for the PSEM conversion factor as this can be derived from the PSEM-specific factor and edible portion factor.

References

Vossenaar M, Arimond M, Deitchler M, Lubowa A, Hotz C, Moursi M. 2020. *An Overview of the Main Pre-Survey Tasks Required for Large-Scale Quantitative 24-Hour Recall Dietary Surveys in Low- and Middle-Income Countries. Washington, DC: Intake – Center for Dietary Assessment/FHI Solutions*. Available at: Intake.org.

Vossenaar M, Crispim SP, Lubowa A, Deitchler M, Moursi M, Arimond M. 2020. *Guidance for the Development of Food Photographs for Portion Size Estimation in Quantitative 24-Hour Dietary Recall Surveys in Low- and Middle-Income Countries.* Washington, DC and Curitaba, Brazil: *Intake* – Center for Dietary Assessment/FHI Solutions and Department of Nutrition, Federal University of Paraná. Available at Intake.org.

Vossenaar M, Deitchler M, Hotz C, Lubowa A, and Ferguson E. 2020. *Routines and Procedures to Test the Accuracy and Precision of Digital Dietary Scales Used in Quantitative 24-Hour Dietary Recall Surveys.* Washington, DC: *Intake* – Center for Dietary Assessment/FHI Solutions. Available at: Intake.org.

Vossenaar M, Hotz C, Lubowa A, Deitchler M, Moursi M, Arsenault J, Colaiezzi B, and Arimond M. 2022. *Guidance for the Use of Standard and Non-Standard Recipes in Quantitative 24-Hour Dietary Recall Surveys: The Simple Ingredient Method. Washington*, DC: *Intake* – Center for Dietary Assessment/FHI Solutions. Available at Intake.org.

Vossenaar M, Hotz C, Lubowa A, Ferguson E, and Deitchler M. 2020. *Recommended Specifications for Dietary Scales for Use in Quantitative 24-Hour Dietary Recall Surveys in Low- and Middle-Income Countries.* Washington, DC: *Intake* – Center for Dietary Assessment/FHI Solutions. Available at: Intake.org.

Vossenaar M, Lubowa A, Hotz C, Deitchler M, Moursi M, Arimond M, Crispim S, and Arsenault J. 2020. *Considerations for the Selection of Portion Size Estimation Methods for Use in Quantitative 24-Hour Dietary Recall Surveys in Low- and Middle-Income Countries.* Washington, DC: *Intake* – Center for Dietary Assessment/FHI Solutions. Available at: Intake.org.

Annex 1. Recommended Procedures for Collecting PSEM-Specific Factor Data for Group I PSEMs

This annex provides step-by-step procedures for primary data collection to derive PSEM-specific factors for Group I PSEMs.

In Box 5, we outline the procedure to determine the gram weight of each unit needed for the use of standard unit size as a PSEM.

In Box 6 to 9, we describe procedures to collect data needed to derive a PSEM-specific factor for the use of proxy materials as a PSEM. We first describe procedures to derive data needed to derive a PSEM-specific factor using the "preferred approach"; these include the density data of the proxy material (Box 6) and the food items being estimated (Box 7 and 8). We then describe the procedures to derive a PSEM-specific factor using the "alternative approach" (Box 9).

Finally, in Box 10. , we describe the procedure to collect the volumes of utensils for use with calibrated household utensils as a PSEM.

Box 5. Recommended Procedure for the Collection of "Grams Per Standard Unit"

Needed when standard unit size is used as a PSEM.

Equipment required

- A high-quality digital dietary scale that meets *Intake* specifications[A]
- A plate or bowl

Preparatory work required

- Before use, all scales must be tested to ensure that they work with acceptable accuracy and precision.[B]
- Create a form for data collection. An example of a data entry form in Excel is provided in Supplementary File 3.

Step 1: Select the food samples

- For each standard unit size that has been identified for use in the FRIL, six food samples should be collected from a range of different sources to capture any variations in size that might exist.[C]
- For some food items, different standard unit sizes may be required, and data collection must be repeated for each one. Each standard unit and corresponding PSEM-specific factor should be labeled accordingly.
    - For commercial items, identify the main sizes or weights from packages. For example, pre-sliced bread may be sold in two distinct loaf sizes (large = 1 kg and small = 500 g), and a separate standard unit weight per slice must be determined for each loaf size.
    - For items such as fruits, vegetables, and some roots and tubers, different unit sizes may have to be defined (e.g., small, medium, large). In some settings, size categories can be established in markets (i.e., some vendors may sort and sell their items according to size).
    - For some food items, size categories may be defined according to specific varieties that occur in distinct sizes. For example, some mango, banana, or avocado varieties are typically small, medium, or large, depending on the variety. This approach should be reserved for situations where there are only a few distinct varieties or size categories available for a particular food item across the survey area.
    - If the standard unit size is distinctly different in different survey regions, separate data should be derived for each area where the standard unit size is different.
- Prepare the food item as it is described in the FRIL (i.e., with or without inedible parts). Remove all inedible parts that are not included in the food description. For commercial food items, remove any packaging.

Step 2: Determine the weight of the empty plate or bowl (one-time preparation)[D]

- Weigh the dry empty plate or bowl on a digital scale and record the measurement to the nearest gram.

Step 3: Determine the weight of each food sample

- Clean and dry the plate or bowl before each use to avoid erroneous measurements.
- Put the food sample on the plate or bowl and place it on the scale
- Record the measurement to the nearest gram (measurement includes the weight of the plate or bowl)
- Calculate the mean weight of all food samples that represent a unit size (i.e., mean of six food samples) and subtract the weight of the empty plate or bowl.[E]

Step 4: Calculate the average "unit size" for the food sample[E]

- Use the mean weight of the food samples that represent a unit size (calculated in step 3).
- Calculate the standard deviation (SD) of the weight of all food samples that represent a unit size. This can be done in Excel using the function STDEV.S.
- Calculate the coefficient of variation (CV) as the SD divided by the mean.
- If the set of weight values has a CV > 0.10, check your data as follows:
    - If there are obvious outliers, recheck the weights of the outlier samples.
    - If the weights of the obvious outliers are correct, obtain six new samples and include their weights in the mean.
    - If the weights of the obvious outliers are incorrect, then correct the values.
    - Recalculate the CV and repeat this step as necessary.

The Number of Food Samples and Measurements Needed per Standard Unit Size

Steps	Number of items/food samples	Number of measurements
Step 2: Weigh the empty plate or bowl (one-time preparation)	1 plate or bowl	1 per plate or bowl
Step 3: Weigh the food sample (measurement includes the weight of the plate or bowl)	6 food samples	1 per food sample

[A] Essential features include that the scale be electronic with digital readout, a maximum weight capacity ranging from 10 kg to 15 kg (or 5 kg if non-standard recipes are not collected during the 24-hour recall interview), 1 gram display increments, and a precision of 1% across the load range. For guidance on dietary scale specifications, see Vossenaar M, Hotz C, Lubowa A, Ferguson E, and Deitchler M. 2020. *Recommended Specifications for Dietary Scales for Use in Quantitative 24-Hour Dietary Recall Surveys in Low- and Middle-Income Countries.* Washington, DC: *Intake* – Center for Dietary Assessment/FHI Solutions. Available at Intake.org.

[B] For guidance on dietary scale testing, see Vossenaar M, Deitchler M, Hotz C, Lubowa A, and Ferguson E. 2020. *Routines and Procedures to Test the Accuracy and Precision of Digital Dietary Scales Used in Quantitative 24 - Hour Dietary Recall Surveys.* Washington, DC: *Intake* – Center for Dietary Assessment/FHI Solutions. Available at Intake.org.

[C] If it is not feasible to collect six food samples, a minimum of four is acceptable.

[D] The weight of the empty plate or bowl is later subtracted from the weight of the plate or bowl with the food sample; this is done to avoid having to tare the scale. Since the weight of the plate or bowl is used for all calculations, this step must be carried out with a high level of accuracy.

[E] These calculations can be done in Excel, using the spreadsheet provided in Supplementary File 3.

Box 6. Recommended Procedure for Collecting Density Data for a Proxy Material

Needed when proxy materials such as playdough, raw rice, or kinetic sand® are used as a PSEM.

Equipment required

- A high-quality digital dietary scale that meets *Intake* specifications[A]
- A measuring cup (200–300 ml)

Preparatory work required

- Before use, all dietary scales must be tested to ensure that they work with acceptable accuracy and precision.[B]
- Create a form for data collection. An example of a data entry form in Excel is provided in Supplementary File 3.

Step 1: Determine the weight of the empty measuring cup (one-time preparation)[C]

- Weigh the dry empty measuring cup on a digital scale and record the measurement to the nearest gram.

Step 2: Determine the volume of the measuring cup using water (one-time preparation)[D]

- Clean and dry the measuring cup before each use to avoid erroneous measurements.
- Put the empty measuring cup on a digital scale.
- Fill the measuring cup with water up to the brim. Fill it most of the way and then top it off with a spoon. If any water is spilled, wipe the scale and start over.
- Record the measurement to the nearest gram (measurement includes the weight of the measuring cup).
- Do this three times, each time with a different sample of water.
- Average the three measurements and subtract the weight of the empty measuring cup.[E]

Step 3: Weigh the measuring cup filled with the proxy material for each sample

- Clean and dry the measuring cup before each use to avoid erroneous measurements.
- Fill the measuring cup tightly with proxy material, up to the brim, without leaving any space. A knife or similar edge should be used to remove excess proxy material above the brim and to create an even surface.
- Put the filled measuring cup on a digital scale and record the measurement to the nearest gram (measurement includes the weight of the measuring cup).
- Do this three times, each time with a different sample of proxy material.
- Average the three measurements and subtract the weight of the empty measuring cup.[E]

Step 4: Calculate the average density of the proxy material[E]

- Calculate the density of the proxy material as the average weight of the proxy material (calculated in step 3) divided by the average volume of the measuring cup (calculated in step 2).

The Number of Proxy Material Samples and Measurements Needed

Steps	Number of proxy material samples	Number of measurements
Step 1: Weigh the empty measuring cup (one-time preparation)	1 measuring cup	1 per empty measuring cup
Step 2: Weigh the measuring cup filled with water to determine its volume (measurement includes the weight of the measuring cup), (one-time preparation)	3 samples of water	1 per measuring cup filled with water
Step 3: Weigh the proxy material (measurement includes the weight of the measuring cup)	3 samples of proxy material	1 per measuring cup filled with proxy material

[A] Essential features include that the scale be electronic with digital readout, a maximum weight capacity ranging from 10 kg to 15 kg (or 5 kg if non-standard recipes are not collected during the 24-hour recall interview), 1 gram display increments, and a precision of 1% across the load range. For guidance on dietary scale specifications, see Vossenaar M, Hotz C, Lubowa A, Ferguson E, and Deitchler M. 2020. *Recommended Specifications for Dietary Scales for Use in Quantitative 24-Hour Dietary Recall Surveys in Low- and Middle-Income Countries.* Washington, DC: *Intake* – Center for Dietary Assessment/FHI Solutions. Available at Intake.org.

[B] For guidance on dietary scale testing, see Vossenaar M, Deitchler M, Hotz C, Lubowa A, and Ferguson E. 2020. *Routines and Procedures to Test the Accuracy and Precision of Digital Dietary Scales Used in Quantitative 24 - Hour Dietary Recall Surveys*. Washington, DC: *Intake* – Center for Dietary Assessment/FHI Solutions. Available at Intake.org.

[C] The weight of the empty measuring cup is later subtracted from the weight of the measuring cup filled with playdough; this is done to avoid having to tare the scale. Since the weight of the measuring cup is used for all calculations, this step must be carried out with a high level of accuracy.

[D] The weight of the water in the measuring cup equals the volume because the density of water is 1 g/ml.

[E] These calculations can be done in Excel, using the spreadsheet provided in Supplementary File 3.

Box 7. Recommended Procedure for the Collection of Food Density Data Using a Measuring Cup (Method 1)

Needed when proxy materials[A] or calibrated household utensils are used as a PSEM or when substitutions are allowed[B]

Equipment required

- A high-quality digital dietary scale that meets *Intake* specifications[C]
- A transparent cup or small pitcher (500–700 ml) with a wide and flat top edge.

Preparatory work required

- Before use, all dietary scales must be tested to ensure that they work with acceptable accuracy and precision.[D]
- Create a form for data collection. An example of a data entry form in Excel is provided in Supplementary File 3.

Step 1: Select the food samples

- For each food item, obtain six samples.[E]
- Prepare the food item as it is described in the FRIL (i.e., with or without inedible parts). Remove all inedible parts that are not included in the food item description.

Step 2: Determine the weight of the empty cup or small pitcher (one-time preparation)[F]

- Weigh the dry empty cup or small pitcher on a digital scale and record the measurement to the nearest gram.

Step 3: Determine the volume of the cup or small pitcher using water (one-time preparation)

- Clean and dry the cup or small pitcher before each use to avoid erroneous measurements.
- Put the empty cup or small pitcher on a digital scale.
- Fill the cup or small pitcher with water up to the brim. Fill it most of the way and then top it off with a spoon. If any water is spilled, wipe the scale and start over.
- Record the measurement to the nearest gram (measurement includes the weight of the cup or small pitcher).
- Do this three times, each time with a different sample of water.
- Average the three measurements and subtract the weight of the empty cup or small pitcher.[G]

Step 4: Determine the weight of each food sample

- Clean and dry the cup or small pitcher before each use to avoid erroneous measurements.
- Fill the cup or small pitcher with the food sample.
    - For liquids or viscous food samples, the volume can be brought to the level by pouring most of the volume in and then adding small amounts with a spoon until it is level with the rim.
    - For thicker or chunky food samples special care must be taken to get accurate measures.
    - Add the food sample to the cup or small pitcher slowly, bit by bit, and ensure that there are no air pockets left in the cup or small pitcher. This can be observed if the measuring cup or small pitcher is transparent.
    - At the same time, avoid compressing the food item excessively as this may result in an overestimate of density.
    - The cup or small pitcher can be overfilled somewhat and then leveled by running a flat blade over the rim of the cup to remove the excess amount.

- For each food sample, weigh the filled cup or small pitcher a single time and record the weight to the nearest gram.
- Calculate the average weight of all food samples (i.e., an average of six food samples) and subtract the weight of the empty cup or small pitcher.[G]

Step 5: Calculate the average density of the food item[G]

- Divide the average weight of the food sample (g) (calculated in step 4) by the average volume of the food sample (ml) (calculated in step 3) to obtain the density for each food sample.
- Calculate the SD of the density of all food samples. This can be done in Excel using the function STDEV.S.
- Calculate the CV as the SD divided by the mean.
- If the set of density values has a CV > 0.10, check your data as follows:
    - If there are obvious outliers, recheck the density of the outlier samples.
    - If the densities of the obvious outliers are correct, obtain six new samples and include their densities in the mean.
    - If the densities of the obvious outliers are incorrect, then correct the values.
    - Recalculate the CV and repeat this step as necessary

The Number of Food Samples and Measurements Needed

Steps	Number of items/food samples	Number of measurements
Step 2: Weigh the cup or small pitcher (one-time preparation)	1 cup	1 per empty cup
Step 3: Weigh the cup or small pitcher filled with water to determine its volume (measurement includes the weight of the cup or small pitcher), (one-time preparation)	3 samples of water	1 per cup filled with water
Step 4: Weigh the food sample (measurement includes the weight of the plate)	6 food samples	1 per cup filled with food sample (measurement includes weight of the cup)

[A] When using proxy materials, the density of the proxy material itself must also be collected.

[B] Food density data are also needed when substitutions are allowed with the use of direct weight or graduated portion-size food photographs.

[C] Essential features include that the scale be electronic with digital readout, a maximum weight capacity ranging from 10 kg to 15 kg (or 5 kg if non-standard recipes are not collected during the 24-hour recall interview), 1 gram display increments, and a precision of 1% across the load range. For guidance on dietary scale specifications, see Vossenaar M, Hotz C, Lubowa A, Ferguson E, and Deitchler M. 2020. *Recommended Specifications for Dietary Scales for Use in Quantitative 24-Hour Dietary Recall Surveys in Low- and Middle-Income Countries.* Washington, DC: *Intake* – Center for Dietary Assessment/FHI Solutions. Available at Intake.org.

[D] For guidance on dietary scale testing, see Vossenaar M, Deitchler M, Hotz C, Lubowa A, and Ferguson E. 2020. *Routines and Procedures to Test the Accuracy and Precision of Digital Dietary Scales Used in Quantitative 24 - Hour Dietary Recall Surveys.* Washington, DC: *Intake* – Center for Dietary Assessment/FHI Solutions. Available at Intake.org.

[E] If it is not feasible to collect six food samples, a minimum of four is acceptable.

[F] The weight of the empty measuring cup is later subtracted from the weight of the measuring cup filled with the food sample; this is done to avoid having to tare the scale. Since the weight of the measuring cup is used for all calculations, this step must be carried out with a high level of accuracy.

[G] These calculations can be done in Excel, using the spreadsheet provided in Supplementary File 3.

Box 8. Recommended Procedure for the Collection of Food Density Data Using Water Displacement (Method 2)

Needed when proxy materials or calibrated household utensils are used as a PSEM or when substitutions are allowed.[A]

Equipment required

- A high-quality digital dietary scale that meets *Intake* specifications[B]
- A graduated cylinder with markings large enough for the food item being measured (e.g., 500 ml)
- A plate or bowl
- A jug with water
- A cup to fill the graduated cylinder

Preparatory work required

- Before use, all dietary scales must be tested to ensure that they work with acceptable accuracy and precision.[C]
- Create a form for data collection. An example of a data entry form in Excel is provided in Supplementary File 3.

Step 1: Select the food samples

- For each food item, obtain six samples.[D]
- Prepare the food item as it is described in the FRIL (i.e., with or without inedible parts). Remove all inedible parts that are not included in the food item description.

Step 2: Determine the weight of the empty plate or bowl (one-time preparation)[E]

- Weigh the dry empty plate or bowl on a digital scale and record the measurement to the nearest gram.

Step 3: Determine the weight of each food sample

- Clean and dry the plate or bowl before each use to avoid erroneous measurements.
- Put the food sample on the plate or bowl and place it on the scale
- Record the measurement to the nearest gram (measurement includes the weight of the plate or bowl)
- Calculate the average weight of all food samples (i.e., an average of six food samples) and subtract the weight of the empty plate or bowl.[F]

Step 4: Determine the volume of each food sample

- Fill a graduated cylinder partway with water (such that it is almost full but not overflowing when the food sample is fully submerged) and record the volume to the nearest ml. It is useful, but not essential, to fill the cylinder to a volume indicated by the markings (e.g., 40 ml).
- Submerge the food sample and record the volume to the nearest ml. If the food item does not sink or it absorbs water, this method is not appropriate to use.
- Record the measurement to the nearest ml.
- For each set of measurements, subtract the initial reading (volume of the water only) from the final reading (volume with water and sample) to obtain the volume of each sample.

Step 5: Calculate the average density of the food item[F]

- Divide the average weight of the food sample (g) (calculated in step 3) by the average volume of the same food sample (ml) (calculated in step 4) to obtain the density for each food sample.

- Calculate the SD of the density of all food samples (this can be done in Excel using the function STDEV.S.)
- Calculate the CV as the SD divided by the mean.
- If the set of density values has a CV > 0.10, check your data as follows:
    - If there are obvious outliers, recheck the density of the outlier samples.
    - If the densities of the obvious outliers are correct, obtain six new samples and include their densities in the mean.
    - If the densities of the obvious outliers are incorrect, then correct the values.
    - Recalculate the CV and repeat this step as necessary.

The Number of Food Samples and Measurements Needed

Steps	Number of items/food samples	Number of measurements
Step 2: Weigh the empty plate (one-time preparation)	1 plate	1 per empty plate
Step 3: Weigh the food sample (measurement includes the weight of the plate)	6 food samples	1 per food sample
Step 4: Read the volume indicated on the graduated cylinder (read the volume of the empty cylinder and the cylinder with the food sample)	6 food samples	1 per food sample

[A] Food density data are also needed when substitutions are allowed with the use of direct weight or graduated portion-size food photographs.

[B] Essential features include that the scale be electronic with digital readout, a maximum weight capacity ranging from 10 kg to 15 kg (or 5 kg if non-standard recipes are not collected during the 24-hour recall interview), 1 gram display increments, and a precision of 1% across the load range. For guidance on dietary scale specifications, see Vossenaar M, Hotz C, Lubowa A, Ferguson E, and Deitchler M. 2020. *Recommended Specifications for Dietary Scales for Use in Quantitative 24-Hour Dietary Recall Surveys in Low- and Middle-Income Countries.* Washington, DC: *Intake* – Center for Dietary Assessment/FHI Solutions. Available at Intake.org.

[C] For guidance on dietary scale testing, see Vossenaar M, Deitchler M, Hotz C, Lubowa A, and Ferguson E. 2020. *Routines and Procedures to Test the Accuracy and Precision of Digital Dietary Scales Used in Quantitative 24 - Hour Dietary Recall Surveys.* Washington, DC: *Intake* – Center for Dietary Assessment/FHI Solutions. Available at Intake.org.

[D] If it is not feasible to collect six food samples, a minimum of four is acceptable.

[E] The weight of the empty plate or bowl is later subtracted from the weight of the plate or bowl with the food sample; this is done to avoid having to tare the scale. Since the weight of the plate or bowl is used for all calculations, this step must be carried out with a high level of accuracy.

[F] These calculations can be done in Excel, using the spreadsheet provided in Supplementary File 3.

Box 9. Recommended Procedure for the Collection of PSEM-Specific Factors Using the Alternative Approach

Needed when proxy weight materials that can be shaped are used as a PSEM and the preferred approach cannot be used.[A]

Equipment required

- A high-quality digital dietary scale that meets *Intake* specifications[B]
- High-quality commercial playdough (300–500 g)
- A plate or bowl

Preparatory work required

- Before use, all dietary scales must be tested to ensure that they work with acceptable accuracy and precision.[C]
- Create a form for data collection. An example of a data entry form in Excel is provided in Supplementary File 3.

Step 1: Select the food samples

- For each food item, obtain six samples.[D]
- Prepare the food item as it is described in the FRIL (i.e., with or without inedible parts). Remove all inedible parts that are not included in the food item description.

Step 2: Determine the weight of the empty plate or bowl (one-time preparation)[E]

- Weigh the dry empty plate or bowl on a digital scale and record the measurement to the nearest gram.

Step 3: Determine the weight of the playdough that represents the size of each food sample

- Clean and dry the plate or bowl before each use to avoid erroneous measurements.
- Carefully mold a piece of playdough that represents its size (i.e., visually the same volume). Confirm that the sizes look similar by looking at the food item and piece of playdough from different angles.
- Put the molded piece of playdough on the plate or bowl and place it on the scale.
- Do this three times (i.e., mold and weigh the corresponding shape three separate times) and record each measurement to the nearest gram.
- Average the three measurements and subtract the weight of the empty plate or bowl.[F]

Step 4: Determine the weight of each food sample

- Clean and dry the plate or bowl before each use to avoid erroneous measurements.
- Put the food sample on the plate or bowl and place it on the scale
- Record the measurement to the nearest gram (measurement includes the weight of the plate or bowl)
- Calculate the average weight of all food samples (i.e., an average of six food samples) and subtract the weight of the empty plate or bowl.[F]

Step 5: Calculate the average PSEM-specific factor for the food sample[F]

- Divide the average weight of the food sample (g) (calculated in step 4) by the average weight of the volume of the proxy material (calculated in step 3) to obtain the PSEM-specific factors for each food sample.
- Calculate the average PSEM-specific factor for all food samples.

- Calculate the SD of the PSEM-specific factor of all food samples. This can be done in Excel using the function STDEV.S.
- Calculate the CV as the SD divided by the mean.
- If the set of PSEM-specific factor values has a CV > 0.10, check your data as follows:
    - If there are obvious outliers, recheck the PSEM-specific factor values of the outlier samples.
    - If the PSEM-specific factor values of the obvious outliers are correct, obtain six new samples and include their PSEM-specific factor values in the mean.
    - If the PSEM-specific factor values of the obvious outliers are incorrect, then correct the values.
    - Recalculate the CV and repeat this step, as necessary.

The Number of Food Samples and Measurements Needed

Steps	Number of items/food samples	Number of measurements
Step 2: Weigh the empty plate (one-time preparation)	1 plate	1 per empty plate
Step 3: Weigh the playdough (measurement includes the weight of the plate)	3 samples of playdough to represent the amount of 6 food samples (18 in total)	3 per food sample (the piece of playdough is molded 3x and each piece is weighed once)
Step 4: Weigh the food sample (measurement includes the weight of the plate)	6 food samples	1 per food sample

[A] This alternative approach is needed when using playdough as a PSEM and the density of the food item cannot be obtained.

[B] Essential features include that the scale be electronic with digital readout, a maximum weight capacity ranging from 10 kg to 15 kg (or 5 kg if non-standard recipes are not collected during the 24-hour recall interview), 1 gram display increments, and a precision of 1% across the load range. For guidance on dietary scale specifications, see Vossenaar M, Hotz C, Lubowa A, Ferguson E, and Deitchler M. 2020. *Recommended Specifications for Dietary Scales for Use in Quantitative 24-Hour Dietary Recall Surveys in Low- and Middle-Income Countries*. Washington, DC: *Intake* – Center for Dietary Assessment/FHI Solutions. Available at Intake.org.

[C] For guidance on dietary scale testing, see Vossenaar M, Deitchler M, Hotz C, Lubowa A, and Ferguson E. 2020. *Routines and Procedures to Test the Accuracy and Precision of Digital Dietary Scales Used in Quantitative 24 - Hour Dietary Recall Surveys.* Washington, DC: *Intake* – Center for Dietary Assessment/FHI Solutions. Available at Intake.org.

[D] If it is not feasible to collect six food samples, a minimum of four is acceptable.

[E] The weight of the empty plate or bowl is later subtracted from the weight of the plate or bowl with the food sample; this is done to avoid having to tare the scale. Since the weight of the plate is used for all calculations, this step must be carried out with a high level of accuracy.

[F] These calculations can be done in Excel, using the spreadsheet provided in Supplementary File 3.

Box 10. Recommended Procedure for the Collection of Volume of Utensils

Needed when calibrated household utensils are used as a PSEM.

Equipment required

- A high-quality digital dietary scale that meets *Intake* specifications[A]
- A measuring cup (200–300 ml)

Preparatory work required

- Before use, all dietary scales must be tested to ensure that they work with acceptable accuracy and precision.[B]
- Create a form for data collection. An example of a data entry form in Excel is provided in Supplementary File 3.

Step 1: Select the household utensils to be calibrated

- Select the 1 utensil of a given make and size to be used as a PSEM in the survey,
- Step 2: Determine the weight of the empty cup (one-time preparation),[C]
- Weigh the dry empty cup on a digital scale and record the measurement to the nearest gram.

Step 3: Determine the volume of the utensil using water for each utensil sample

- Clean and dry the utensil before each measurement to avoid erroneous measurements.
- Fill the utensil with water to the brim.
- Carefully pour the water from the utensil into the cup.
- Do this 10 times so that the amount of water in the cup represents the total volume of 10 of the same-sized utensil.
- Place the cup on the scale and record the weight of the water in the cup to the nearest gram.
- Subtract the weight of the empty cup and divide the weight of the water in the cup by 10 to derive the volume of the utensil. [D]

Step 3: Determine the average volume of the utensil using water for each utensil sample

- Average the volume of the three utensils selected to represent a utensil of a given size (calculated in step 3).

The Number of Food Samples and Measurements Needed

Steps	Number of items/food samples	Number of measurements
Step 2: Weigh the empty cup (one-time preparation)	1 cup	1 per empty cup
Step 3: Weigh the measuring cup with water to determine the volume of the utensil (measurement includes weight of the cup)	1 utensil of a given make and size	1 per utensil (each volume corresponds to that of 10 utensils)

[A] Essential features include that the scale be electronic with digital readout, a maximum weight capacity ranging from 10 kg to 15 kg (or 5 kg if non-standard recipes are not collected during the 24-hour recall interview), 1 gram display increments, and a precision of 1% across the load range. For guidance on dietary scale specifications, see Vossenaar M, Hotz C, Lubowa A, Ferguson E, and Deitchler M. 2020. *Recommended Specifications for Dietary Scales for Use in Quantitative 24-Hour Dietary Recall Surveys in Low- and Middle-Income Countries.* Washington, DC: *Intake* – Center for Dietary Assessment/FHI Solutions. Available at Intake.org.

[B] For guidance on dietary scale testing, see Vossenaar M, Deitchler M, Hotz C, Lubowa A, and Ferguson E. 2020. *Routines and Procedures to Test the Accuracy and Precision of Digital Dietary Scales Used in Quantitative 24 - Hour Dietary Recall Surveys*. Washington, DC: *Intake* – Center for Dietary Assessment/FHI Solutions. Available at Intake.org.

[C] The weight of the empty plate or bowl is later subtracted from the weight of the plate or bowl with the food sample; this is done to avoid having to tare the scale. Since the weight of the plate or bowl is used for all calculations, this step must be carried out with a high level of accuracy.

[D] These calculations can be done in Excel, using the spreadsheet provided in Supplementary File 3.

Annex 2. Guidance for the Monitoring of Playdough Density During Data Collection

This annex provides guidance for the monitoring of playdough density during data collection. The density of each enumerator's supply of playdough should be determined before beginning data collection for the survey. This is done so that the playdough density used by each enumerator can be monitored regularly; this is not done to assign the playdough density used in the PSEM-specific conversion factors (this is done centrally as described in Annex 1, Box 6).

During the survey, the monitoring of the density of each enumerator's supply of playdough should be done regularly (e.g., at least once a week). Each enumerator should use the same measurement cup throughout the survey. When this is done, the volume and weight of the measuring cup will need to be determined only once.

Below, we first describe the one-time preparations to determine the weight and volume of each measuring cup (Box 11). Then, we describe the procedure to determine the density of playdough regularly (Box 12).

Box 11. One-Time Preparations Required for the Regular Monitoring of Playdough Density

Equipment required

- A high-quality digital dietary scale that meets *Intake* specifications[A]
- A measuring cup (200–300 ml) that allows the playdough to be leveled off at the top with a knife and to be removed easily after the measurement

Preparatory work required

- Before use, all dietary scales must be tested to ensure that they work with acceptable accuracy and precision.[B]
- Create a form for data collection. An example of a data entry form in Excel is provided in Supplementary File 4.

Step 1: Determine the weight of the empty measuring cup (one-time preparation)[C]

- Weigh the dry empty cup on a digital scale and record the measurement to the nearest gram.

Step 2: Determine the volume of the measuring cup using water (one-time preparation)[D]

- Clean and dry the cup before each use to avoid erroneous measurements.
- Put the empty cup on a digital scale.
- Fill the cup with water up to the brim. Fill it most of the way and then top it off with a spoon. If any water is spilled, wipe the scale and start over.
- Record the measurement to the nearest gram (measurement includes the weight of the measuring cup).
- Do this three times, each time with a different sample of water.
- Average the three measurements and subtract the weight of the empty cup.[E]
- Label the measuring cup with the name and ID of the interviewer. Also, record the average volume and weight of the cup on the label. Use a permanent marker.

The Number of Food Samples and Measurements Needed

Steps	Number of items/samples	Number of measurements
Step 1: Weigh the empty cup (one-time preparation)	1 cup	1 per empty cup
Step 2: Weigh the cup filled with water to determine its volume (measurement includes weight of the cup) (one-time preparation)	3 samples of water	1 per cup filled with water

[A] Essential features include that the scale be electronic with digital readout, a maximum weight capacity ranging from 10 kg to 15 kg (or 5 kg if non-standard recipes are not collected during the 24-hour recall interview), 1 gram display increments, and a precision of 1% across the load range. For guidance on dietary scale specifications, see Vossenaar M, Hotz C, Lubowa A, Ferguson E, and Deitchler M. 2020. *Recommended Specifications for Dietary Scales for Use in Quantitative 24-Hour Dietary Recall Surveys in Low- and Middle-Income Countries.* Washington, DC: *Intake* – Center for Dietary Assessment/FHI Solutions. Available at Intake.org.

[B] For guidance on dietary scale testing, see Vossenaar M, Deitchler M, Hotz C, Lubowa A, and Ferguson E. 2020. *Routines and Procedures to Test the Accuracy and Precision of Digital Dietary Scales Used in Quantitative 24 - Hour Dietary Recall Surveys.* Washington, DC: *Intake* – Center for Dietary Assessment/FHI Solutions. Available at Intake.org.

[C] The weight of the empty measuring cup is later subtracted from the weight of the measuring cup filled with playdough. This is done to avoid having to tare the scale. Since the weight of the measuring cup is used for all calculations, this step must be carried out with a high level of accuracy.

[D] The weight of the water in the measuring cup equals the volume because the density of water is 1 g/ml.

[E] These calculations can be done in Excel, using the spreadsheet provided in Supplementary File 4.

Box 12. Recommended Procedure for the Regular Monitoring of Playdough during Data Collection

This procedure should be done separately using the playdough carried by each enumerator.

Equipment required

- A high-quality digital dietary scale that meets *Intake* specifications[A]
- A measuring cup (200–300 ml) for which the weight and volume were previously determined
- A knife

Preparatory work required

- Before use, all dietary scales must be tested to ensure that they work with acceptable accuracy and precision.[B]
- Create a form for data collection. An example of a data entry form in Excel is provided in Supplementary File 4.

Step 1: Weigh the measuring cup filled with playdough

- Clean and dry the measuring cup before each use to avoid erroneous measurements.
- Fill the measuring cup tightly with proxy material, up to the brim, without leaving any space. A knife or similar edge should be used to remove excess proxy material above the brim and to create an even surface.
- Put the filled cup on a digital scale and record the measurement to the nearest gram (measurement includes the weight of the measuring cup).
- Do this three times, each time with a different sample of playdough from the same enumerator's supply of playdough.
- Average the three measurements of the cup filled with playdough and subtract the weight of the empty cup to calculate the average weight of the playdough.

Step 2: Calculate the density of the playdough

- Calculate the density[C] of the playdough and the change in density[D] of the playdough for that specific enumerator's supply from when data collection for the survey began.
- If the density of the playdough for any enumerator differs by more than 10% (which usually corresponds to ±0.1 g/ml) from the beginning of the survey, it should be replaced with unused playdough of the same type and from the same manufacturer.
- If the density of the playdough is acceptable, put the playdough back into the container carried by the enumerator.
- Follow the same procedures to determine the density of the new playdough to be issued to the enumerator.

.

The Number of Playdough Samples and Measurements Needed

Steps	Number of playdough samples	Number of measurements
One-Time Preparations (Box 11)		
Step 1: Weigh the empty measuring cup (one-time preparation)	1 cup	1 per empty cup
Step 2: Weigh the measuring cup filled with water to determine its volume (measurement includes weight of the measuring cup), (one-time preparation)	3 samples of water	1 per cup filled with water (measurement includes weight of the cup)
Regular Monitoring of Playdough (Box 12)		
Step 1: Weigh the measuring cup filled with playdough to determine its volume (measurement includes weight of the measuring cup), (one-time preparation)	3 samples of playdough	1 per cup filled with playdough

[A] Essential features include that the scale be electronic with digital readout, a maximum weight capacity ranging from 10 kg to 15 kg (or 5 kg if non-standard recipes are not collected during the 24-hour recall interview), 1 gram display increments, and a precision of 1% across the load range. For guidance on dietary scale specifications, see Vossenaar M, Hotz C, Lubowa A, Ferguson E, and Deitchler M. 2020. *Recommended Specifications for Dietary Scales for Use in Quantitative 24-Hour Dietary Recall Surveys in Low- and Middle-Income Countries*. Washington, DC: *Intake* – Center for Dietary Assessment/FHI Solutions. Available at Intake.org.

[B] For guidance on dietary scale testing, see Vossenaar M, Deitchler M, Hotz C, Lubowa A, and Ferguson E. 2020. *Routines and Procedures to Test the Accuracy and Precision of Digital Dietary Scales Used in Quantitative 24 - Hour Dietary Recall Surveys.* Washington, DC: *Intake* – Center for Dietary Assessment/FHI Solutions. Available at Intake.org.

[C] The density of the playdough is calculated as the average of weight of the playdough divided by the average volume of the cup.

[D] The change in density is calculated as the density of the playdough at the start of the survey minus the density of the playdough on the day of monitoring.

Annex 3. Recommended Procedures for Collecting Edible Portion Factor Data

This annex provides a detailed step-by-step procedure for primary data collection of edible portion factors for foods (including ingredients).

Box 13. Recommended Procedure for the Collection of Edible Portion Factors

Equipment required

- A high-quality digital dietary scale that meets *Intake* specifications[A]
- Three appropriately sized bowls:
    - Bowl A should be large enough to contain the food sample.
    - Bowl B should be large enough to contain the inedible portion.
    - Bowl C should be large enough to contain the edible portion.

Preparatory work required

- Before use, all dietary scales must be tested to ensure that they work with acceptable accuracy and precision.[B]
- Create a form for data collection. An example of a data entry form in Excel is provided in Supplementary File 5.

Step 1: Select the food samples

- For each food, obtain six samples.[C]
- The proportion of inedible to edible amounts can vary with the size of the food sample. Therefore, for commonly consumed foods for which the food sizes vary, it may be necessary to collect separate edible portion factors for those sizes or those varieties.[D] The different sizes should be indicated in the FRIL.

Step 2: Determine the weight of each empty bowls (one-time preparation)

- Weigh the dry empty bowl on a digital scale and record the measurement to the nearest gram. [E]

Step 3: Determine the weight of each food sample (including both edible and inedible portions)

- Clean and dry bowl A before each use to avoid erroneous measurements.
- Put the first food sample in bowl A and place it on the scale.
- Record the measurement to the nearest gram (measurement includes the weight of the bowl).
- Repeat these steps for each food sample.
- Calculate the average weight of all food samples (i.e., an average of six food samples) and subtract the weight of the empty bowl.[F]

Step 4: Determine the weight of the inedible portion of each food sample (only the inedible portion)

- Clean and dry bowl B before each use to avoid erroneous measurements.
- Remove the inedible portion of the food sample and place this in Bowl B. Remove waste, i.e. inedible portion, as would typically be done in household food preparation.

- Put the inedible portion (i.e., waste) of the first food sample in bowl B and place on the scale.
- Record the measurement to the nearest gram (measurement includes the weight of the bowl).
- Repeat these steps for each food sample.
- Calculate the average weight of all inedible portions of the food samples (i.e., an average of six food samples) and subtract the weight of the empty bowl.[F]

Step 5: Determine the weight of the edible portion of each food sample (only the edible portion)

- Clean and dry bowl C before each use to avoid erroneous measurements.
- Put the edible portion of the first food sample in bowl C and place it on the scale.
- Record the measurement to the nearest gram (measurement includes the weight of the bowl).
- Repeat these steps for each food sample.
- Calculate the average weight of all edible portions of the food samples (i.e., an average of six food samples) and subtract the weight of the empty bowl.[F]

Step 6: Calculate the average edible and inedible portion factor based on all the food samples[F]

- For each food sample, calculate the edible portion factor by dividing the average weight of the edible portion (calculated in step 5) by the average weight of the entire food sample (calculated in step 3).
- For each food sample, calculate the inedible portion factor by dividing the average weight of the waste (calculated in step 4) by the average weight of the entire food sample (calculated in step 3).
- The edible and inedible portion factors should add up to approximately 1.0.
- Calculate the SD of the edible portion factor using the Excel function STDEV.S.
- Calculate the CV in Excel as the SD divided by the mean.
- If the set of edible portion factor values has a CV > 0.10, check your data as follows:
    - If there are obvious outliers, recheck the edible portion factors of the outlier samples.
    - If the edible portion factors of the obvious outliers are correct, obtain six new samples and include their edible portion factors in the mean.
    - If the edible portion factors of the obvious outliers are incorrect, then correct the values.
    - Recalculate the CV and repeat this step, as necessary.

The Number of Food Samples and Measurements Needed

Steps	Number of items/food samples	Number of measurements
Step 2: Weigh the 3 empty bowls (one-time preparation)	1 bowl	1 per bowl
Step 3: Weigh the food sample (measurement includes the weight of the bowl)	6 food samples	1 per food sample
Step 4: Weigh the inedible portion of the food sample (measurement includes the weight of the bowl)	6 food samples	1 per food sample
Step 5: Weigh the edible portion of the food sample (measurement includes the weight of the bowl)	6 food samples	1 per food sample

[A] Essential features include that the scale be electronic with digital readout, a maximum weight capacity ranging from 10 kg to 15 kg (or 5 kg if non-standard recipes are not collected during the 24-hour recall interview), 1 gram display increments, and a precision of 1% across the load range. For guidance on dietary scale specifications, see Vossenaar M, Hotz C, Lubowa A, Ferguson E, and Deitchler M. 2020. *Recommended Specifications for Dietary Scales for Use in Quantitative 24-Hour Dietary Recall Surveys in Low- and Middle-Income Countries*. Washington, DC: *Intake* – Center for Dietary Assessment/FHI Solutions. Available at Intake.org.

[B] For guidance on dietary scale testing, see Vossenaar M, Deitchler M, Hotz C, Lubowa A, and Ferguson E. 2020. *Routines and Procedures to Test the Accuracy and Precision of Digital Dietary Scales Used in Quantitative 24 - Hour Dietary Recall Surveys.* Washington, DC: *Intake* – Center for Dietary Assessment/FHI Solutions. Available at Intake.org.

[C] If it is not feasible to collect six food samples, a minimum of four is acceptable.

[D] For example, for "small" bananas and "large" bananas that differed in average weight by >130 g, the edible portion factors differed by 17 percentage points. In this case, using a single average edible portion factor may introduce unnecessary error, particularly if bananas are commonly consumed.

[E] The weight of the empty bowl is later subtracted from the weight of the bowl with the food sample; this is done to avoid having to tare the scale. Since the weight of the plate is used for all calculations, this step must be carried out with a high level of accuracy.

[F] These calculations can be done in Excel, using the spreadsheet provided in Supplementary File 5.

Annex 4. Available Resources for Published Density and Edible Portion Factors

Some recommended sources with published values for food density and edible portion factors are listed here and can be downloaded from the *Intake* online resource library, available at Intake.org.

Box 14. Available Resources for Food Density Data

Country/region	Description	Citation
Australia & New Zealand	Database in Excel with a very extensive food listing (>16,000 items). Density is provided for a selection of items (>5,000 items). Densities reported in the "Weight in grams "column were analyzed (n=564), borrowed (n=486), estimated (n=922), imputed (n=3665), provided by industry (n=41), or taken from label data (n=36). Data sources are well documented.	AUSNUT 2011-13 Food Measures Database File.
Belgium	40-page pdf file in French including data on weight per household measure, portion or unit, 'partie comestible' (edible portion), 'facteur de réduction' (reduction factor), 'perte de poids lors de la préparation' (weight loss due to preparation) and 'absorption de graisse lors de la préparation' (fat absorption). Densities can be computed from weight of household measures (volume of household measures provided) for some foods.	Conseil Supérieur d'Hygiène. Poids et mesures. Manuel de quantification standardisée des denrées alimentaires en Belgique. Bruxelles: G. De Backer, président du Conseil Supérieur d'Hygiène; 2005.
Canada	60-page pdf file provides an extensive listing of foods and recipes. Densities for numerous foods can be computed from provided weight and measure (most are reported as volume, e.g., 125 ml).	Health Canada. Nutrient value of some common foods. Ottawa: Her Majesty the Queen in Right of Canada, represented by the Minister of Health Canada; 2008.
FAO/INFOODS	20-page pdf file includes data to convert volume into weight and vice-versa. It includes a very compact list of key foods and recipes. Data were collected from the literature, various national food composition tables (e.g., USDA and UK FSA) and measurements conducted by the authors. The tables include "Density in g/ml (including mass and bulk density)", "Specific Gravity" and "BiblioID" (citation).	Charrondiere UR, Haytowitz D, Stadlmayr B. FAO/INFOODS Density Database. Version 2.0. Rome: FAO; 2012.
New Zealand	CSM.FT files with densities for > 3000 foods. These include (i) specific gravity for liquids, (ii) mass density for semi-solids and solids with regular shapes and (iii) bulk density for powders, grains and foods with air.	New Zealand FOODfiles 2016 Version 01. The New Zealand Institute for Plant & Food Research Limited and the Ministry of Health
South Africa	200-page pdf file with extensive food and recipe listing providing "Mass of edible food in gram" per unit or household portion. Densities can be computed for most foods from weight of household measures (volume of household measures provided).	SAFOODS. 2018. SAMRC Food Quantities Manual for South Africa. 3rd Edition. (ebook). Cape Town: South African Medical Research Council.

Country/region	Description	Citation
Uganda	Excel file with conversion factors for portion size estimation methods. Volumes (g/ml) are provided for almost 800 foods and recipes as a ratio.	Hotz, Lubowa, Sison, Moursi, Loechl, 2012. A Food Composition Table for Central and Eastern Uganda. HarvestPlus Technical Monograph 9. Washington, DC and Cali: International Food Policy Research Institute (IFPRI) and International Center for Tropical Agriculture (CIAT).(Related Excel)
USA	26-page scan of document published in 1977 provides a detailed food and recipe listings with "weight of 1 cup" for all items (also SD and number of samples).	Fulton L, Matthews E, Davis C. Average weight of a measured cup of various foods. U.S. Department of Agriculture, Home Economics Research Report 41, 1977.
USA	Web-based platform with USDA Food Composition Databases (standard reference & brand food products). The search function works well and the list of foods and recipes is the most extensive one available. For some foods, weights per household measures are provided. Densities can be computed from weight of household measures.	U.S. Department of Agriculture, Agricultural Research Service. FoodData Central, 2019. fdc.nal.usda.gov.

Box 15. Available Resources for Edible Portion Factor Data

Country/region	Description	
Japan	Food composition table in excel includes a column for "refuse" presented as %.	Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan. Standards Tables of Food Composition in Japan -2015- (Seventh Revised Edition) Documentation and Table.
UK	13-page scan of pdf file (hence the search function does not work). The original pdf can be purchased online. Section 4.2 Edible Conversion Factors and Calculation of Nutrient Content for Foods 'As Purchased' or 'As Served' (pp. 502–511) presents edible conversion factors; this includes a description of the inedible parts (e.g., skin, bone) and an edible conversion factor as ratio.	Finglas, P.M., Roe, M.A., Pinchen, H.M., Berry, R., Church, S.M., Dodhia, S.K., Farron-Wilson, M, Joanne McCardle, Swan, G, 2015a. In: McCance and Widdowson's. The Composition of Foods. Seventh Summary Edition. The Royal Society of Chemistry, Cambridge, UK.
West Africa	Excel spreadsheet and pdf file with food composition data for West Africa. Includes column with "Edible portion coefficient 1 (from as purchased to as described)".	FAO/INFOODS Food Composition Table for Western Africa (2019)

Supplementary Files

Supplementary File 1	Excel spreadsheet showing conversions for portion size data into grams of edible portion
Supplementary File 2	Templates for PSEM conversion factor databases
Supplementary File 3	Excel spreadsheet for the collection of PSEM-specific factors for Group I PSEMs
Supplementary File 4	Excel spreadsheet for the monitoring of playdough density
Supplementary File 5	Excel spreadsheet for the collection of edible portion factor data

intake.org