Article

Development of a Digital Photographic Food Atlas as a Portion Size Estimation Aid in Japan

Nana Shinozaki 1, Kentaro Murakami 1,*, Keiko Asakura 2, Shizuko Masayasu 3 and Satoshi Sasaki 1

1 Department of Social and Preventive Epidemiology, School of Public Health, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan; nana-s@m.u-tokyo.ac.jp (N.S.); stssasaki@m.u-tokyo.ac.jp (S.S.)
2 Department of Environmental and Occupational Health, School of Medicine, Toho University, 5-21-16 Omori-Nishi, Ota-ku, Tokyo 143-8540, Japan; keiko.asakura@med.toho-u.ac.jp
3 Ikurien-Naka, 3799-6 Sugaya, Ibaraki 311-0105, Japan; sizuko-masa@themis.ocn.ne.jp
* Correspondence: kenmrkm@m.u-tokyo.ac.jp; Tel.: +81-3-5841-7872

Abstract: This study aimed to develop a digital photographic food atlas as a portion size estimation aid. Commonly consumed foods were identified from the 5512-day weighed dietary records of 644 Japanese adults. Portion sizes were determined based on the market research and distribution of food consumption in the dietary records. Each food item was classified into one of two photo types: a series of photographs showing gradually increasing portion sizes or guide photographs representing a range of portion sizes and food varieties in one photograph. Photographs of the food were taken at an angle of 42°, along with appropriate reference objects such as chopsticks. In total, 209 food and dish items were included in the food atlas. Series of photographs were taken for 105 items that are not usually served in predetermined amounts (e.g., rice and pasta), whereas guide photographs were taken for 104 items usually served in predetermined amounts (e.g., bananas and cookies). Moreover, photographs were taken for 12 kinds of household measurement items, such as cups and glasses. The food atlas could be a valuable tool for estimating the portion size in dietary surveys. Evaluating the validity of this food atlas for portion size estimation is warranted.

Keywords: food atlas; photograph; digital image; dietary record; portion size; Japan; dietary assessment

1. Introduction

Portion size estimation is an essential component of dietary assessment [1]. Misestimation of portion size may increase estimation errors of food and nutrient intake, potentially causing a misinterpretation of the association between diet and health outcomes [1]. Although weighing foods is considered a gold standard to assess food amounts, it is time-consuming and requires high motivation from participants [1,2]. This hinders the use of weighing methods in large-scale or long-term dietary surveys [1–3].

Therefore, various portion size estimation aids have been developed, including household utensils, food models, and food photographs [4]. Food photographs are widely used in dietary surveys because they are less burdensome for respondents. Moreover, they are easy to use for interviewees, portable and inexpensive, and cover a broad range of foods [4–7]. During data collection, respondents can report the amounts of foods they consumed by selecting a single picture or indicating a fraction, multiple, or percentage of the amount shown in a photograph [8]. A previous review suggested that food atlases (a photo album of various food portion sizes) are more accurate than a limited number of photographs in other formats [4].

Food atlases must be developed on a country-by-country basis, based on food availability and dietary intake data [3,6]. Presently, food atlases or comprehensive food photograph databases have been developed in many countries in Europe [3,6,8–17], North and South America [5,18–22], the Middle East [23,24], Africa [25–27], and Asia [28–33]. However, in
Japan, there is no comprehensive food atlas that has been developed using a data-driven approach. For future dietary surveys, it is essential to develop a food atlas that encompasses a wide range of foods and dishes consumed in Japan based on dietary intake data. Therefore, this study aimed to develop a digital photographic food atlas to help estimate portion size in dietary surveys in Japan.

2. Materials and Methods

2.1. Data Source

The development of the food atlas was based on weighed dietary data derived from two surveys. Since both the surveys have been described previously [34,35], only a brief explanation has been provided here. The first survey was conducted between 2002 and 2003 in four prefectures in Japan (2003 survey), and the second one was conducted in 2013 in 23 prefectures (2013 survey). The 2003 survey participants included healthy females (n = 126) aged 30–69 years and their cohabitating spouses (n = 126), while the 2013 survey included healthy females (n = 196) and males (n = 196) aged 20–69 years. In total, 644 participants provided their dietary data. A weighed dietary record (DR) was collected over 16 days (three weekdays and one weekend day in each of the four seasons) in the 2003 survey and for 4 days (three working days and one non-working day during the winter season) in the 2013 survey. Local registered dietitians used written and verbal instructions to explain to the participants how to complete the DR using recording sheets and a digital scale (KD-173 (2003 survey) and KD-812WH (2013 survey), Tanita, Tokyo, Japan). Recording sheets were checked by the registered dietitians at the local center and then again at the study center. The registered dietitians coded each food in the “food item” column of the recording sheet at the study center, following uniform procedures using food codes from the Standard Tables of Food Composition in Japan [36,37]. Estimated intakes of energy and nutrients from each food item were computed based on the intake of food items and their nutrient contents [38]. Moreover, each dish in the “dish item” column in the DR was coded using the dish codes of a recently developed dish composition database in Japan [39,40]. In the 2003 survey, 10 participants provided less than 16 days of the DR: 4 days (n = 2) and 8 days (n = 8). Consequently, the dataset comprised 5512-day dietary data (3944 days in the 2003 survey and 1568 days in the 2013 survey), including 1591 food codes and 371 dish codes.

2.2. Selection of Foods and Dishes

We systematically selected commonly consumed foods and dishes for the food atlas (Figure 1). First, the frequency of consumption, sum of the consumed amount, and energy contribution in the entire population were calculated for each food code and dish code [10,41]. Following this, the top 100 food codes and top 100 dish codes were identified for each criterion, resulting in 300 food codes and 300 dish codes chosen, including duplicates. After eliminating the duplications from the union of the top 100 items for each criterion, 172 food codes and 137 dish codes remained. Next, we excluded the following items that did not require a photograph for portion size estimation:

1. Foods not eaten as they are (e.g., flour, starch);
2. Items that can be estimated using standard portions without food photographs (e.g., boiled eggs, candy);
3. Items that can be estimated by pictures of household measurement items (e.g., soy sauce can be estimated by tablespoons);
4. Items that can be substituted by other items consumed more commonly (e.g., the food code 17042 “mayonnaise, whole egg type” can be substituted by the food code 17043 “mayonnaise, egg yolk type”) [39];
5. Miscellaneous dish codes (e.g., dish code 11522 “beverages [details unknown]”) [39].
Figure 1. Selection flow of the foods and dishes for the food atlas.

After excluding 75 food codes and 28 dish codes, 97 food codes and 109 dish codes were retained. We excluded 58 items common between the food codes and dish codes (e.g., food code 16011 “fermented alcoholic beverage, wine, red” was excluded to avoid duplication with dish code 11517 “wine”). Finally, 148 codes (52 food codes and 96 dish codes) were selected for inclusion in the food atlas.

After the list of food and dish codes was defined, we selected a specific food and dish item to purchase for each code based on the DR. For dish codes consisting of similar types of multiple dishes, we selected the dish that appeared most frequently in the DR (e.g., for dish code 10105 “curry and rice/hash and rice,” we selected curry and rice). If there were several distinctive items in a single code, we divided the code into subdivisions for clarity of classification. For instance, dish code 10308 “yakisoba” (stir-fried noodles with vegetables and meat) was divided into “packaged ready-to-eat yakisoba” and “yakisoba on a plate.” Similarly, if a food item had a large variation in appearance, food packaging, and serving method, the food code was divided into certain subdivisions. In this way, 26 codes were divided into 87 items (i.e., 2–11 subdivisions for each code) based on the type of food or variations in appearances. The remaining 122 codes were not divided. Consequently, 209 food and dish items (including 87 items that are variations of 26 codes and 122 items without variations) were included in the food atlas. Based on the DR, we determined how
to cut and prepare each food item to represent the state in which it is usually eaten. Food and dishes were purchased from popular restaurants, local and online supermarkets, and convenience stores.

2.3. Determination of the Type of Photographs

Based on previous studies [10,24,29,41], we decided to take photographs of the foods and dishes either as a series of photographs (Figure 2) or guide photographs (Figure 3). A series of photographs depicts gradually increasing portion sizes for foods and dishes that are usually not served in predetermined amounts (e.g., white rice, curry and rice, pasta, and vegetable salads). A guide photograph represents a range of the common portion sizes in one photograph for foods and dishes that are usually served in predetermined amounts (e.g., bananas, cookies, doughnuts, and milk in cartons).

![Figure 2](image_url)

Figure 2. Example of a series of photographs for curry and rice. The portion size gradually increases from photo (a–g).

We classified each food and dish item into either photograph type. If a food item could be represented in both types of photographs, then the photograph type was selected according to the variability of sizes in the market, portion size distribution in the DR, and authors’ knowledge.

In addition to the series of photographs and guide photographs, we took photographs of household measurement items as options to estimate the portion size of beverages and seasonings (Figure 4). These household measurement items included various cups, glasses, meal spoons, and measuring spoons.
2.4. Determination of Portion Sizes

We determined the portion size of each food and dish according to the type of photograph. For guide photographs, we purchased various products from popular local and online supermarkets, where we selected items that represent a variety of portion sizes and the appearance of each food and dish item in a single photo.

The number of portion sizes in a series of photographs was set as seven [10,41]. The first (smallest) and seventh (largest) portion sizes were the 5th and 95th percentiles of the weight consumed in the DR, respectively [8,10,42]. The second to sixth portion sizes were determined based on equal increments on a log scale from the 5th to the 95th percentile of the weight of food consumed in one eating session, allowing the portions to increase proportionately [10,24]. For dishes consisting of food ingredients with different physical characteristics, such as curry and rice, the portion of each part was determined according to the commercial products or common recipes. For instance, for curry and rice, the portions of white rice and curry sauce were determined separately based on the average ratio of white rice to curry sauce calculated from two beef curry dishes purchased from a popular restaurant chain (CURRY HOUSE CoCo Ichibanya). Foods usually eaten after heating (raw vegetables and mushrooms) were microwaved as appropriate to obtain the yield factor (i.e., the rate of weight change before and after cooking). Each portion size was then calculated as the weight of the raw ingredient for each portion multiplied by the yield factor.

For photographs of cups and glasses, the number of portion sizes was set as five or seven based on the size of the cups or glasses. The maximum portion size was defined as the maximum volume (1 cm from the edge) of each cup or glass. Subsequently, the maximum volume divided by the number of portion sizes (five or seven) was used as the increase in each portion from the first to sixth portion sizes.
2.5. Preparation of Tableware

Tableware was selected from popular tableware stores in Japan (Nitori Co. Ltd., Ikea Japan K.K., Ryohin Keikaku Co. Ltd., Tokyo, Japan). To make it easy to see the color and shape of foods, we chose plain white plates, except for a wooden bowl or tray for foods that were white in color, such as grated radish. Furthermore, because rice, soup, and beverages are frequently consumed using a wide variety of tableware, we selected rice bowls, soup bowls, and cups and glasses of assorted sizes and shapes. This was done so that people could estimate the portions using tableware that was similar to what they usually used.

2.6. Weighing of Foods

Each portion of food was weighed using a calibrated cooking scale, KW-320 (Tanita, Tokyo, Japan), measuring up to 300 g in increments of 0.1 g, 300–1500 g in increments of 0.5 g, and 1500–3000 g in increments of 1 g. In the series of photographs, each portion was adjusted to equal each portion calculated from the DR as closely as possible. The weights of the beverages were calculated by multiplying the liquid volume (mL) by the specific gravity (g/mL) of each drink item in the Standard Tables of Food Composition in Japan [38]. The weight of each portion was recorded and entered into a database.

2.7. Photography

To ensure the quality of food photography, the authors attended three lecture sessions by a professional food photographer. The authors (N.S. and K.M.) captured all photographs using a 26.2-megapixel camera, EOS-RP (Canon Inc., Tokyo, Japan).

We mainly used a 26-cm dinner plate, 15-cm and 11-cm side plates, 21-cm and 18-cm bowls, and a 40 × 30-cm wooden tray, as appropriate. Photos of foods and dishes were taken at an angle of 42°, which is considered an average viewing angle from a sitting position at a table and the best balance between depth and height [11,14,43]. The photographs to select rice and soup bowls and cups and glasses were taken at an angle of 30°. This angle was determined in consultation with the professional food photographer to make it easier to see the differences in tableware size. Photographs of cups and glasses for assessing the liquid volume of beverages were taken horizontally, with scale lines representing each portion added using Microsoft PowerPoint for Microsoft 365 (Microsoft, Redmond, WA, USA), as shown in Figure 4b,c. One or two standard reference objects, such as a 23-cm chopstick, 21-cm knife, 19-cm fork, 19-cm spoon, or 14-cm dessert spoon, which were considered most appropriate for each food and dish, were included in the pictures to help recognize the quantity of foods and dishes and the size of the plate [24,42]. To achieve consistent exposure and white balance, we used a shutter speed of 1/50; aperture, F10; ISO, 1600; and a grey card (GIN-ICHI Co., Tokyo, Japan). The camera was connected to a laptop computer, and the consistency in the pictures was reviewed using the software program EOS Utility, version 3.13.30 for Windows (Canon Inc., Tokyo, Japan). Lighting was provided using two softboxes (58 watts). In addition, a soft diffuser disc panel was used to diffuse the light softly. Each photograph of the food and dish item was assigned a picture ID corresponding to its original food and dish code.

3. Results

Of 209 food and dish items included in the food atlas, 105 were photographed as a series of photographs and 104 as guide photographs.

3.1. Series of Photographs

Figure 2 shows an example of a series of photographs of curry and rice, and Table 1 shows a list of the items in the series of photographs. Most items had seven portions, whereas white rice and miso soups had up to three to six portions for small- and medium-sized bowls, because there was no capacity to serve large portions.
Table 1. List of items in the series of photographs  

| Category | Picture ID 1 | Food/Dish Name | Number of Portions |
|----------|-------------|----------------|--------------------|
| Food item | F1039      | Soba (buckwheat noodles) | 7 |
|          | F1044      | Somen (thin wheat noodles) | 7 |
|          | F1088s     | White rice in a small rice bowl | 6 ² |
|          | F1088m     | White rice in a medium rice bowl | 6 ² |
|          | F1088l     | White rice in a large rice bowl | 7 |
|          | F1128      | Soba (buckwheat noodles) | 7 |
|          | F2003      | Simmered konjac balls | 7 |
|          | F2017      | French fries | 7 |
|          | F2023      | Grated yam | 7 |
|          | F4039      | Deep-fried bean curd, chopped | 7 |
|          | F4040      | Fried tofu, shredded | 7 |
|          | F6061      | Cabbage, shredded | 7 |
|          | F6065      | Cucumber, sliced | 7 |
|          | F6084      | Burdock, sliced, microwaved | 7 |
|          | F6134      | Radish, shredded | 7 |
|          | F6153      | Onion, thinly sliced | 7 |
|          | F6191      | Eggplant, chopped, microwaved | 7 |
|          | F6207      | Chinese chive, microwaved | 7 |
|          | F6214      | Shredded carrots | 7 |
|          | F6226      | Spring onion, chopped | 7 |
|          | F6233      | Chinese cabbage, chopped, microwaved | 7 |
|          | F6245      | Green bell pepper, shredded, microwaved | 7 |
|          | F6264      | Broccoli, microwaved | 7 |
|          | F6291      | Bean sprouts, microwaved | 7 |
|          | F6312      | Lettuce, cut into bite-sized pieces | 7 |
|          | F7012      | Strawberry | 7 |
|          | F7049      | Persimmon, sliced | 7 |
|          | F7077      | Watermelon, sliced | 7 |
|          | F8001      | Enoki mushroom, microwaved | 7 |
|          | F8016      | Brown beech mushroom, microwaved | 7 |
|          | F8039      | Shiitake mushroom, sliced, microwaved | 7 |
|          | F9045      | Wakame seaweed | 7 |
|          | F10070     | Japanese eel | 7 |
|          | F10263     | Canned tuna, served in a dish | 7 |
|          | F11183     | Bacon, shredded | 7 |
|          | F13025b    | Yoghurt, served in a bowl | 7 |
|          | F14020a    | Margarine, served with a butter knife | 7 |
|          | F14020b    | Margarine, served on a slice of bread | 7 |
|          | F17036     | Ketchup | 7 |
|          | F17039     | Japanese-style dressing | 7 |
|          | F17043     | Mayonnaise | 7 |
| Dish item | D10104     | Zousui (porridge of rice and vegetables) soup | 7 |
|          | D10105a    | Japanese curry and white rice | 7 |
|          | D10105b    | Thai green curry and jasmine rice | 7 |
|          | D10109     | Fried rice | 7 |
|          | D10112     | Beef rice bowl | 7 |
|          | D10113     | Pork cutlet rice bowl | 7 |
|          | D10114     | Oyako-don (chicken and egg rice bowl) | 7 |
|          | D10116     | Grilled eel and rice | 7 |
|          | D10119     | Chirashizushi (sushi rice topped with various raw fish pieces) | 7 |
|          | D10301     | Udon (thick wheat noodles) with soup | 7 |
|          | D10302     | Soba (buckwheat noodles) with soup | 7 |
|          | D10305     | Ramen | 7 |
|          | D10307a    | Napolitan (ketchup-based spagetti) | 7 |
|          | D10307b    | Penne with cheese sauce | 7 |
|          | D10308a    | Yakisoba (fried noodles) on a plate | 7 |
Table 1. Cont.

| Category | Picture ID | Food/Dish Name                                                                 | Number of Portions |
|----------|------------|---------------------------------------------------------------------------------|--------------------|
| D10312   |            | Soki soba (traditional noodle in Okinawa)                                        | 7                  |
| D10401   |            | Okonomiyaki (savoury pancake with various ingredients)                           | 7                  |
| D10501   |            | Nikujaga (meat and potato stew)                                                  | 7                  |
| D10502   |            | Simmered squid and taro                                                          | 7                  |
| D10503   |            | Baked sweet potato                                                               | 7                  |
| D10506   |            | Potato salad                                                                     | 7                  |
| D10801   |            | Spinach seasoned with sesame sauce                                               | 7                  |
| D10802   |            | Ohitashi (boiled spinach)                                                        | 7                  |
| D10803   |            | Vinegared cucumber and wakame seaweed                                            | 7                  |
| D10805   |            | Grated daikon radish                                                             | 7                  |
| D10810a  |            | Vegetable mix salad                                                             | 7                  |
| D10810b  |            | Shrimp and broccoli salad                                                        | 7                  |
| D10810c  |            | Bean salad                                                                       | 7                  |
| D10814   |            | Macaroni salad                                                                   | 7                  |
| D10815   |            | Vinegared mozuku seaweed                                                         | 7                  |
| D10819   |            | Kinpira (chopped burdock root and carrot cooked in sugar and soy sauce)          | 7                  |
| D10822   |            | Simmered squash                                                                  | 7                  |
| D10823   |            | Simmered Japanese butterbur and deep-fried tofu                                  | 7                  |
| D10826   |            | Simmered hijiki seaweed                                                          | 7                  |
| D10835   |            | Vegetable stir-fry                                                               | 7                  |
| D10904   |            | Cut apples                                                                       | 7                  |
| D11001a  |            | Tuna sashimi                                                                     | 7                  |
| D11001b  |            | Tuna strips                                                                       | 7                  |
| D11123   |            | Sliced beef steak                                                                | 7                  |
| D11125   |            | Ginger fried pork                                                                | 7                  |
| D11134   |            | Chinese stir-fry containing green peppers and meat                               | 7                  |
| D11141   |            | Pork cutlet                                                                       | 7                  |
| D112204  |            | Tamago-yaki (Japanese rolled omelette)                                            | 7                  |
| D11701s  |            | Miso soup (with tofu and green onion) in a small soup bowl                        | 3                  |
| D11701m  |            | Miso soup (with tofu and green onion) in a medium soup bowl                       | 6                  |
| D11701l  |            | Miso soup (with tofu and green onion) in a large soup bowl                        | 7                  |
| D11703s  |            | Tonjiru (miso soup with pork and vegetables) in a small soup bowl                 | 3                  |
| D11703m  |            | Tonjiru (miso soup with pork and vegetables) in a medium soup bowl                | 5                  |
| D11703I  |            | Tonjiru (miso soup with pork and vegetables) in a large soup bowl                 | 7                  |
| D11711a  |            | Creamy corn soup                                                                 | 7                  |
| D11711b  |            | Clam chowder                                                                      | 7                  |
| D11714   |            | White stew                                                                       | 7                  |
| D11718   |            | Yosenabe (seafood and vegetable hot pot)                                          | 7                  |
| D11802a  |            | Tsukudani of konbu seaweed (simmered konbu)                                      | 7                  |
| D11802b  |            | Laver boiled in soy sauce                                                        | 7                  |
| D11805   |            | Cubed daikon kimchi                                                              | 7                  |
| D11806   |            | Pickled scallions                                                                | 7                  |
| D11807a  |            | Pickled cucumber                                                                  | 7                  |
| D11807b  |            | Pickled Chinese cabbage                                                           | 7                  |

1 For food items, the four- or five-digit number corresponds to the food code in the Standard Tables of Food Composition in Japan [38]. For dish items, the five-digit number corresponds to minor codes in the dish composition database [39]. The alphabet at the end of each code indicates subdivisions. 2 Large portion sizes cannot be served in small and medium bowls.
3.2. Guide Photographs

Examples of the guide photographs are shown in Figure 3, and the list of foods is presented in Table 2. The number of portions selected in a single photograph varied according to the food and dish items, ranging from 2 to 19 (mean: 5.3). We decided to use the same photographs of paper cartons, plastic bottles, or cup bottles for different beverages (e.g., soymilk, milk, and vegetable juice), because these containers are common for various kinds of beverages. Protein and energy bars were photographed due to their increasing popularity, although they did not appear frequently in the DR.

Table 2. List of items in the guide photographs (n = 104).

| Category | Picture ID | Food/Dish Name                              | Number of Portions |
|----------|-----------|---------------------------------------------|--------------------|
| Food item| F1034     | Bread roll                                  | 6                  |
|          | F1088b    | Pre-cooked rice                             | 7                  |
|          | F1117     | Sticky rice cake                            | 6                  |
|          | F4032     | Tofu                                        | 7                  |
|          | F4046     | Natto (fermented soybeans)                  | 4                  |
|          | F6182     | Tomato                                      | 6                  |
|          | F7107     | Banana                                      | 3                  |
|          | F10381    | Chikuwa (Japanese fishcake)                 | 3                  |
|          | F11186    | Sausage                                     | 6                  |
|          | F13025a   | Packed yoghurt                              | 10                 |
|          | F13040    | Cheese                                      | 10                 |
|          | F13020    | Casutera sponge cake                        | 4                  |
|          | F15069    | Anpan (sweet bean-jam bun)                  | 4                  |
|          | F15070    | Cream bun                                   | 3                  |
|          | F15076a   | Croissant                                   | 4                  |
|          | F15076b   | Danish bread                                | 6                  |
|          | F15082a   | Madeleine                                   | 3                  |
|          | F15082b   | Pound cake                                  | 2                  |
| Dish item| D10118    | Rolled sushi                                | 4                  |
|          | D10120    | Rice ball                                   | 13                 |
|          | D10201    | Toast                                       | 6                  |
|          | D10208    | Melon bread (half-melon shaped buns)        | 3                  |
|          | D10208b   | Stick bread                                 | 3                  |
|          | D10209    | Sausage roll                                | 3                  |
|          | D10211    | Sandwich                                    | 6                  |
|          | D10213    | Hamburger                                   | 5                  |
|          | D10304a   | Instant noodle (packet)                     | 3                  |
|          | D10304b   | Instant noodle (Cup Noodle-shaped container) | 3              |
|          | D10304c   | Instant noodle (Donbei-shaped container)    | 3                  |
|          | D10304d   | Instant noodle (other shaped container)     | 2                  |
|          | D10308a   | Yakisoba (UFO)                              | 2                  |
|          | D10308c   | Yakisoba (Peyoung)                          | 2                  |
|          | D10308d   | Yakisoba (other)                            | 2                  |
|          | D10510    | Potato croquette                            | 5                  |
|          | D10622    | Soymilk                                     | 5                  |
|          | D10908    | Mandarin orange                             | 3                  |
|          | D10909    | Various kinds of citrus                     | 8                  |
|          | D11021    | Dried fish                                  | 5                  |
|          | D11046    | Fish jelly products                         | 8                  |
|          | D11102    | Fried gyoza dumplings                       | 4                  |
|          | D11108    | Hamburg steak                               | 5                  |
|          | D11143    | Deep-fried chicken                          | 5                  |
|          | D11301    | Milk                                        | 5                  |
Table 2. Cont.

| Category | Picture ID 1 | Food/Dish Name | Number of Portions |
|----------|--------------|----------------|--------------------|
| D11304  | Coffee-flavoured or fruit-flavoured milk 2 | 5 |
| D11307  | Lactic acid bacteria beverage | 5 |
| D11401  | Kusamochi (rice-flour dumplings mixed with mugwort, stuffed with red bean paste) | 3 |
| D11402  | Manjuu (sponge cake stuffed with red bean paste) | 8 |
| D11412  | Rice cracker | 9 |
| D11419a | Cookie (except sandwich cookie) | 19 |
| D11419b | Sandwich cookie | 9 |
| D11419c | Cracker | 6 |
| D11419d | Energy bar | 6 |
| D11419e | Protein bar | 8 |
| D11420a | Chocolate with nuts | 6 |
| D11420b | Chocolate candy bar | 5 |
| D11420c | Chocolate snack cake | 4 |
| D11420d | Chocolate-coated biscuit stick (e.g., Pocky) | 4 |
| D11420e | Chocolate-coated biscuit stick (e.g., Lumonde) | 6 |
| D11420f | Chocolate-coated biscuit | 12 |
| D11420g | Other chocolate snacks (e.g., chocolate puffs) | 8 |
| D11420h | Chocolate bar without nuts or cookies (e.g., Ghana) | 7 |
| D11420i | Chocolate balls without nuts or cookies (e.g., Meltykiss) | 8 |
| D11420j | Baked chocolate (e.g., Galbo) | 2 |
| D11420k | Small chocolate pieces (e.g., Apollo) | 4 |
| D11423a | Doughnut with a hole | 6 |
| D11423b | Doughnut without a hole | 6 |
| D11425a | Ice cream bar | 7 |
| D11425b | Ice cream cup | 6 |
| D11425c | Iced monaka, iced sandwich | 8 |
| D11425d | Ice cream cone | 3 |
| D11425e | Other ice cream | 6 |
| D11426  | Jelly | 8 |
| D11427a | Financier | 3 |
| D11427b | Baumkuchen | 5 |
| D11427c | Pie cookie | 3 |
| D11427d | Brownie and gateau chocolat | 6 |
| D11427e | Swiss roll | 5 |
| D11427f | Apple pie | 4 |
| D11427g | Strawberry sponge cake | 5 |
| D11427h | Cheesecake | 6 |
| D11427i | Cheese tart | 4 |
| D11427j | Strawberry tart | 3 |
| D11427k | Muffin | 2 |
| D11501a | Coffee in a take-away cup | 4 |
| D11501b | Canned coffee | 3 |
| D11502  | Black tea 3 | 6 |
| D11503  | Other tea (e.g., barley tea, oolong tea) 3 | 6 |
| D11504  | Water, sugar-free carbonated water, 0 kcal beverage 3 | 6 |
| D11505  | Sports drink 3 | 6 |
| D11506  | Cocoa, Milo 3 | 6 |
| D11507  | Energy drink | 4 |
| D11508  | Vegetable juice, green juice 2 | 5 |
| D11509  | Fruit juice 2 | 5 |
| D11515a | Japanese sake (bottles) | 6 |
| D11515b | Japanese sake (paper cartons) | 4 |
| D11515c | Japanese sake (cup bottles) 4 | 6 |
| D11516a | Canned beer and happoushu (sparkling alcoholic beverages) | 4 |
| D11516b | Bottled beer and happoushu (sparkling alcoholic beverages) | 5 |
Table 2. Cont.

| Category | Picture ID | Food/Dish Name                                      | Number of Portions |
|----------|------------|-----------------------------------------------------|--------------------|
|          | D11517     | Bottled wine                                       | 6                  |
|          | D11519     | Japanese shochu (cup bottles)⁴                     | 6                  |
|          | D11520a    | Bottled sour and chuhai                            | 4                  |
|          | D11520b    | Canned sour and chuhai                             | 5                  |
|          | D11520c    | Plum liquor, in bottles and paper cartons          | 5                  |
|          | D11804     | Pickled plum                                       | 3                  |

¹ For food items, the four- or five-digit number corresponds to the food code in the Standard Tables of Food Composition in Japan [38]. For dish items, the five-digit number corresponds to minor codes in the dish composition database [39]. Alphabet at the end of each code indicates subdivisions. ² Photographs of commonly used paper cartons were used. ³ Photographs of commonly used plastic bottles were used. ⁴ Photographs of commonly used cup bottles were used.

3.3. Household Measurement Photographs

A summary of the household measurement items photographed is presented in Table 3. In total, 12 kinds of household measurement items were included in the food atlas. The number of portions was five or seven according to the size of the cups or glasses. As shown in Figure 4, scale lines indicating each portion were added to each cup and glass. However, the portion size of tokkuri (Japanese sake bottle) and choko (small cup for Japanese sake) was set as only the maximum volume, because it was difficult to measure different volumes of liquid in opaque containers. Moreover, they are usually served in 1-cup units. Similarly, the portion size of only the maximum volume is available for meal spoons and measuring spoons.

Table 3. List of household measurement items photographed.

| Items                             | Number of Selections | Number of Portions for Each Cup/Glass/Spoon |
|-----------------------------------|----------------------|---------------------------------------------|
| Cylindrical mugs                  | 3                    | 7                                           |
| Corn-shaped mugs                  | 2                    | 7                                           |
| Teacups                           | 2                    | 7                                           |
| Tall glasses                      | 4                    | 7                                           |
| Short glasses                     | 2                    | 7                                           |
| Wine glasses                      | 4                    | 7                                           |
| Yunomis (Japanese-style teacups)  | 5                    | 5 for a small glass and 7 for others         |
| Tokkuri (sake bottle)             | 2                    | 1 (maximum volume)                          |
| Choko (small cup)                 | 2                    | 1 (maximum volume)                          |
| Measuring spoons                  | 2                    | 1 (maximum volume)                          |
| Meal spoons                       | 3                    | 1 (maximum volume)                          |

4. Discussion

To our knowledge, this is the first comprehensive food atlas designed based on Japanese adult dietary intake data. Although a food atlas was recently published and used in a 24-h dietary recall method in Japan, no information was provided on the data source, development process, or the types and number of photographs [44]. In contrast, our food atlas was developed using multiple day weighed DRs, and includes a detailed description of its development process and structure. Our food atlas includes 209 commonly consumed food and dish items. Of these, 105 and 104 are presented as a series of photographs, and as guide photographs, respectively. Moreover, our food atlas comprises photographs of 12 kinds of household measurement items, including cups and glasses. This food atlas could be a valuable tool to help estimate portion sizes in dietary surveys in Japan.

It is important to use population-based weighed dietary data to determine the type of foods and ranges of portion sizes to be included in a food atlas [42]. Most previous
studies have used population-based dietary data to develop food photographs [3,5,8,10,12,16,17,20,23,24,27,29,32,45,46]. However, some studies have relied on other sources, such as interviews and focus group discussions [25,26], researchers’ observations [47], and experiences of investigators or dietitians [13,14]. This study used the data from the weighed DRs collected over four seasons among Japanese adults. This enabled us to include items representing Japanese dietary habits with day-to-day and seasonal variations in the food atlas.

There is no gold standard for which foods and how many foods should be included in a food atlas. Food atlases should comprise foods with various portion sizes and irregular shapes and sizes [42]. Meanwhile, it is unnecessary to include foods that are readily identifiable from the description (e.g., packaged foods). Including such foods makes the food atlas more expensive and portion size estimation becomes more time-consuming [42]. Therefore, we set inclusion and exclusion criteria for foods and dishes and systematically selected popular and essential items. The number of foods and dishes comprised in this atlas (n = 209) is comparable to that of previously validated food atlases [8,23]. Moreover, if food types and physical attributes are similar, then some photographs may be available to estimate the portion size of other food items not listed in the atlas. In such cases, an evaluation of food appearance and weight adjustments based on food density would be necessary [8,42].

Food atlases should be designed to minimize error in estimating food portion sizes, which is affected by the format of the photographs, such as the number and range of portion sizes depicted [42]. The number of portion sizes per food item varied among previous studies, ranging from one [43,48,49] to eight [18,24,29,43,45]. There is no standard for how many photographs should be shown for a food item [25,43]. However, it has been reported that portion size estimation using one photograph was less accurate than estimation using eight photographs [43]. Another study indicated that four images provided less accurate estimates than eight images, albeit not to a statistically significant extent [19]. This may be because respondents may have difficulty in estimating fractions or multiples of portion size, and fewer photographs lead to a loss of precision [42]. In this study, we chose seven portion sizes for a series of photographs of most items based on previous studies [10,41]. Moreover, as previously recommended [42], we determined the range of the food portions systematically by selecting the 5th to 95th percentiles of the amounts of foods consumed. This helps depict very small and very large portion sizes, making the food atlas suitable for use in populations with variations in the amount of food eaten [42]. The interval of portion sizes depicted between images is also important [42]. We decided to determine portion sizes in a series of photographs based on a log scale so that each portion increased proportionately [19]. For foods depicted as guide photographs, we selected various items based on observations of products at popular local and online supermarkets. This would be helpful to represent in the photograph a range of portion sizes that people typically consume.

The size of photographs also influences estimation error [42]. Although no consistent associations have been observed between the size of photographs and estimation accuracy [19,28,43,50], participants tend to prefer larger photographs to smaller ones [19]. As our food atlas is digital, the photographs can be shown or printed in any size. Previous studies have shown that printed and digital photographs provided similar estimates [5,51]. It is also unclear whether photographs should be labeled with portion size information, such as grams or cups. No existing studies have assessed if labelling will improve accuracy or if it causes bias leading to misreporting [19,52]. The photographs in our food atlas were not labeled to ensure their flexible use. It would be helpful to evaluate the effects of food weight labeling on photographs in future studies.

In this food atlas, each photograph has information regarding weights; therefore, it can help to estimate the amount of consumed food by selecting a specific photograph or reporting the relative portion size to that depicted in the photograph. Given that the food atlas contains photographs of various foods and dishes commonly consumed in
Japan, it is potentially helpful in other countries to estimate Japanese food intake, although portion size distribution should be carefully considered. We can also calculate energy and nutrient intake from the food photographs, because each food and dish item can be connected to the Standard Tables of Food Composition in Japan [38] and the dish composition database [39,40]. In addition, because food photographs are digital data, they can be displayed on various devices (e.g., tablets or laptops) or printed. Thus, the food atlas can be used in combination with various dietary assessment methods, such as both paper-based and web-based FFQs, 24-h recalls, and DRs. However, as a prerequisite for using the food atlas in dietary surveys, the accuracy of dietary intake estimated using the food atlas should be evaluated first.

The strength of this study is the use of DR data obtained over multiple days during four seasons to develop the food atlas. This enabled a data-driven approach to select food and dish items and determine portion sizes, resulting in a comprehensive database of food photographs in Japan. Moreover, each development process was based on scientific principles and practical experience. Nevertheless, this study had several limitations. First, since the dietary data used in this study were obtained from healthy volunteers who were not randomly selected, it may not represent the types and quantities of foods typically consumed in Japan. Food atlases would be more representative if developed based on dietary data from national food consumption surveys [5,50]. However, we did not use the Japanese national dietary survey data because they employ a single-day, household-level DR, and cover only 1 month of the year [53]. It thus seemed inadequate for investigating the portion sizes of various foods. Nevertheless, the weight and height of the participants in this study were similar to those of the general Japanese population [54]. Second, the 2013 survey only included the dietary data obtained in the winter season. This may hinder capturing food eaten in other seasons due to a seasonal variation in dietary intake among Japanese adults [55–57]. Moreover, since the two dietary data used were relatively old, the types and amounts of foods included in the food atlas may not reflect the current diet of the Japanese population. Given that the dietary habits of Japanese people have been gradually changing [58], the foods depicted in the atlas should be updated according to people’s dynamic eating habits and market composition. Third, because the food atlas was developed based on dietary data obtained only from adults, it may not be used to estimate dietary intake in children. A previous study emphasized the need for age-appropriate food photographs to improve the quality of dietary intake data collected from children [59]. Fourth, self-reported dietary data are subject to misreporting [60], leading to errors in portion sizes calculated from the DR. Therefore, further assessment is needed to confirm whether the food atlas encompasses the relevant portion sizes among Japanese people. Fifth, the selection of types and portion sizes of foods and dish items, and the determination of the photographic presentation of each item, involved some subjective judgments. The authors carefully assessed dietary data, conducted market research, and scrutinized recipe books to make the selection and appearance of food and dish items as general as possible. Finally, the food atlas has not yet been evaluated for its validity in estimating portion size. Portion size estimation aids should be validated in the target population [6]. We have completed the validation study in a Japanese population to assess the accuracy of portion size estimates using the food atlas. The differences between the amount of food estimated from the food atlas and the actual food weight are currently under evaluation.

5. Conclusions

We developed a digital photographic food atlas for Japanese adults based on DR data and provided a detailed explanation of each procedure. The food atlas contained 209 commonly consumed food and dish items among Japanese adults and 12 kinds of household measurement items, such as cups and glasses. The food atlas would be a practical and easy-to-use instrument to help estimate portion size both for researchers and respondents. Further research is needed to evaluate how accurately respondents can estimate food portion sizes using the food atlas.
Author Contributions: Conceptualization, N.S. and K.M.; methodology, N.S. and K.M.; formal analysis, N.S. and K.M.; investigation, N.S. and K.M.; data curation, K.A., S.M. and S.S.; writing—original draft preparation, N.S. and K.M.; writing—review and editing, N.S. and K.M.; visualization, N.S. and K.M.; supervision, K.M.; project administration, N.S. and K.M. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by H13 Health Sciences Research Grant (Kenkou-kagakusougou kenkyujiigyou) from the Ministry of Health, Labour and Welfare, Japan; a Health and Labour Sciences Research Grant (no. H23-lyunkankitu (seishuu)-ippan-001) from the Ministry of Health, Labour and Welfare, Japan; and Grant-in-Aid for Research Activity Start-up (JSPS KAKENHI Grant Number 20K23252) from the Japan Society for the Promotion of Science.

Institutional Review Board Statement: Use of data in the 2003 survey and the study protocol of the 2013 survey were approved by the Ethics Committee at the University of Tokyo, Faculty of Medicine (Nos. 3421 and 10005, respectively).

Informed Consent Statement: Written informed consent was obtained from all participants involved in the 2003 and 2013 surveys.

Data Availability Statement: The data presented in this study are available on reasonable request from the corresponding author.

Acknowledgments: The authors thank Naoki Hirota, Akiko Notsu, Ayako Miura, Mitsuru Fukui, Hidemi Todoriki, and Chigusa Date for the data collection of the 2003 survey. We also thank Takahiro Imashimizu for technical guidance in food photography.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

References

1. Almiron-Roig, E.; Navas-Carretero, S.; Emery, P.; Martínez, J.A. Research into Food Portion Size: Methodological Aspects and Applications. *Food Funct.* 2018, 9, 715–739. [CrossRef] [PubMed]
2. Rutishauser, I.H. Dietary Intake Measurements. *Public Health Nutr.* 2005, 8, 1100–1107. [CrossRef] [PubMed]
3. Trolle, E.; Vandevijvere, S.; Ruprich, J.; Ege, M.; Doñková, M.; de Boer, E.; Ocké, M. Validation of a Food Quantification Picture Book Targeting Children of 0–10 Years of Age for Pan-European and National Dietary Surveys. *Br. J. Nutr.* 2013, 110, 2298–2308. [CrossRef]
4. Amoutzopoulos, B.; Page, P.; Roberts, C.; Roe, M.; Cade, J.; Steer, T.; Baker, R.; Hawes, T.; Galloway, C.; Yu, D.; et al. Portion Size Estimation in Dietary Assessment: A Systematic Review of Existing Tools, Their Strengths and Limitations. *Nutr. Rev.* 2020, 78, 885–900. [CrossRef]
5. Nichelle, P.G.; Almeida, C.C.B.; Camey, S.A.; Garmus, L.M.; Elias, V.C.M.; Marchioni, D.M.; da Silva, D.G.; Ocke, M.C.; Slimani, N.; Fisberg, R.M.; et al. Subjects’ Perception in Quantifying Printed and Digital Photos of Food Portions. *Nutrients* 2019, 11, 501. [CrossRef]
6. Szenczi-Cseh, J.; Horváth, Z. Ambrus Validation of a Food Quantification Picture Book and Portion Sizes Estimation Applying Perception and Memory Methods. *Int. J. Food Sci. Nutr.* 2017, 68, 960–972. [CrossRef]
7. De Vlieger, N.M.; Weltert, M.; Molenaar, A.; McCaffrey, T.A.; Rollo, M.E.; Truby, H.; Livingstone, B.; Kirkpatrick, S.I.; Boushey, C.J.; Kerr, D.A.; et al. A Systematic Review of Recall Errors Associated with Portion Size Estimation Aids in Children. *Appetite* 2020, 147, 104522. [CrossRef]
8. Naska, A.; Valanou, E.; Peppa, E.; Katsoulis, M.; Barbouni, A.; Trichopoulou, A. Evaluation of a Digital Food Photography Atlas Used as Portion Size Measurement Aid in Dietary Surveys in Greece. *Public Health Nutr.* 2016, 19, 2369–2376. [CrossRef]
9. Ovaskainen, M.L.; Paturi, M.; Reinivuo, H.; Hannila, M.L.; Sinkko, H.; Lehtisalo, J.; Pynnönen-Polari, O.; Männistö, S. Accuracy in the Estimation of Food Servings against the Portions in Food Photographs. *Eur. J. Clin. Nutr.* 2008, 62, 674–681. [CrossRef]
10. Foster, E.; Hawkins, A.; Barton, K.L.; Stamp, E.; Matthews, J.N.S.; Adamson, A.J. Development of Food Photographs for Use with Children Aged 18 Months to 16 Years: Comparison against Weighed Food Diaries-The Young Person’s Food Atlas (UK). *PLoS ONE* 2017, 12, e0169084. [CrossRef]
11. Vereecken, C.; Dohogne, S.; Coverts, M.; Maes, L. How Accurate Are Adolescents in Portion-Size Estimation Using the Computer Tool Young Adolescents’ Nutrition Assessment on Computer (YANA-C)? *Br. J. Nutr.* 2010, 103, 1844–1850. [CrossRef] [PubMed]
12. Turconi, G.; Guarcello, M.; Berzolari, F.G.; Carolei, A.; Bazzano, R.; Roggi, C. An Evaluation of a Colour Food Photography Atlas as a Tool for Quantifying Food Portion Sizes in Epidemiological Dietary Surveys. *Eur. J. Clin. Nutr.* 2005, 59, 923–931. [CrossRef] [PubMed]
13. Lucas, F.; Niravong, M.; Villeminot, S.; Kaaks, R.; Clavel-Chapelon, F. Estimation of Food Portion Size Using Photographs: Validity, Strengths, Weaknesses and Recommendations. *J. Hum. Nutr. Diet.* 1995, 8, 65–74. [CrossRef]
14. Lillegaard, I.T.L.; Øverby, N.C.; Andersen, L.F. Can Children and Adolescents Use Photographs of Food to Estimate Portion Sizes? *Eur. J. Clin. Nutr.* **2005**, *59*, 611–617. [CrossRef] [PubMed]

15. Vilela, S.; Lopes, C.; Guimaraes, S.; Severo, M.; Rangelova, L.; Petrova, S.; Horvath, Z.; Cseh, J.; Schwetr, A.; Lindtner, O.; et al. Validation of a Picture Book to Be Used in a Pan-European Dietary Survey. *Public Health Nutr.* **2017**, *21*, 1654–1663. [CrossRef] [PubMed]

16. Nissinen, K.; Korkalo, L.; Vepsäläinen, H.; Mäkiranta, P.; Koivusilta, L.; Roos, E.; Erkkola, M. Accuracy in the Estimation of Children’s Food Portion Sizes against a Food Picture Book by Parents and Early Educators. *J. Nutr. Sci.* **2018**, *7*, e35. [CrossRef] [PubMed]

17. Nikolić, M.; Milešević, J.; Zeković, M.; Gribetić, M. The Development and Validation of Food Atlas for Portion Size Estimation in the Balkan Region. *Nutr. Res.* **2018**, *5*, 78. [CrossRef]

18. Kirkpatrick, S.I.; Potischman, N.; Dodd, K.W.; Douglass, D.; Zimmerman, T.P.; Kahle, L.L.; Thompson, F.E.; George, S.M.; Subar, A.F. The Use of Digital Images in 24-Hour Recalls May Lead to Less Misestimation of Portion Size Compared with Traditional Interviewer-Administered Recalls. *J. Nutr. 2016*, *146*, 2567–2573. [CrossRef]

19. Subar, A.F.; Crafts, J.; Zimmerman, T.P.; Wilson, M.; Mittl, B.; Islam, N.G.; McNutt, S.; Potischman, N.; Buday, R.; Hull, S.G.; et al. Assessment of the Accuracy of Portion Size Reports Using Computer-Based Food Photographs Aids in the Development of an Automated Self-Administered 24-Hour Recall. *J. Am. Diet Assoc.* **2010**, *110*, 55–64. [CrossRef] [PubMed]

20. Lazarte, C.E.; Encinas, M.E.; Alegre, C.; Granfeldt, Y. Validation of Digital Photographs, as a Tool in 24-h Recall, for the Improvement of Dietary Assessment among Rural Populations in Developing Countries. *Nutr. J. 2012*, *11*, 61. [CrossRef] [PubMed]

21. Bernal-Orozco, M.F.; Vizmanos-Lamotte, B.; Rodriguez-Rocha, N.P.; Macedo-Ojeda, G.; Orozco-Valero, M.; Rovillé-Saussé, F.; León-Estrada, S.; Márquez-Sandoval, F.; Fernández-Ballart, J.D. Validation of a Mexican Food Photograph Album as a Tool to Visually Estimate Food Amounts in Adolescents. *Br. J. Nutr. 2013*, *109*, 944–952. [CrossRef] [PubMed]

22. Jacques, S.; Lemieux, S.; Lamarche, B.; Laramée, C.; Corneau, L.; Lapointe, A.; Tessier-Grenier, M.; Robitaille, J. Development of a Web-Based 24-h Dietary Recall for a French-Canadian Population. *Nutrients 2016*, *8*, 724. [CrossRef] [PubMed]

23. Tueni, M.; Mounayar, A.; Birloouez-Aragon, I. Development and Evaluation of a Photographic Atlas as a Tool for Dietary Assessment Studies in Middle East Cultures. *Public Health Nutr.* **2012** , *15*, 1023–1028. [CrossRef] [PubMed]

24. Al Marzoogi, H.M.; Burke, S.J.; al Ghazali, M.R.; Duffy, E.; Yousuf, M.H.S. et al. The Development of a Food Atlas of Portion Sizes for the United Arab Emirates. *J. Food Compos. Anal.* **2015**, *43*, 140–148. [CrossRef]

25. Venter, C.S.; MacIntyre, U.E.; Vorster, H.H. The Development and Testing of a Food Portion Photograph Book for Use in an African Population. *J. Hum. Nutr. Diet. 2009*, *22*, 207–217. [CrossRef] [PubMed]

26. Asakura, K.; Uechi, K.; Masayasu, S.; Sasaki, S. Sodium Sources in the Japanese Diet: Difference between Generations and Sexes. *Nutrients 2017* , *9*, 1082. [CrossRef] [PubMed]

27. Flax, V.L.; Thakwalakwa, C.; Schnefke, C.H.; Stobaugh, H.; Phuka, J.C.; Coates, J.; Rogers, B.; Bell, W.; Colaiezzi, B.; Muth, M.K. Validation of a Digitally Displayed Photographic Food Portion-Size Estimation Aid among Women in Urban and Rural Malawi. *Public Health Nutr.* **2019**, *22*, 3140–3150. [CrossRef]

28. Vletter, L.E.; van Staveren, W.; den Tonkelaar, N.; de Vries, J.A.; de Vries, P. Food Composition in Japan, Fifth Revised and Enlarged Edition. *Official Gazette Co-Operation of Japan: Tokyo, Japan, 2010. (In Japanese)*
38. Shinozaki, N.; Murakami, K.; Masayasu, S.; Sasaki, S. Validity of a Dish Composition Database for Estimating Protein, Sodium and Potassium Intakes against 24 h Urinary Excretion: Comparison with a Standard Food Composition Database. Public Health Nutr. 2020, 23, 1297–1306. [CrossRef]

39. Foster, E.; Hawkins, A.; Simpson, E.; Adamson, A.J. Developing an Interactive Portion Size Assessment System (IPSAS) for Use with Children. J. Hum. Nutr. Diet. 2014, 27, 18–25. [CrossRef] [PubMed]

40. Nelson, M.; Haraldsdóttir, J. Food Photographs: Practical Guidelines II. Development and Use of Photographic Atlases for Assessing Food Portion Size. Public Health Nutr. 1998, 1, 231–237. [CrossRef]

41. Nelson, M.; Atkinson, M.; Darbyshire, S. Food Photography I: The Perception of Food Portion Size from Photographs. Br. J. Nutr. 1994, 72, 649–663. [CrossRef]

42. Matsushita, Y.; Takahashi, T.; Asahi, K.; Harashima, E.; Takahashi, H.; Tanaka, H.; Tsumuraya, Y.; Sarukura, N.; Furuta, M.; Tanaka, H.; et al. Validation of Improved 24-Hour Dietary Recall Using a Portable Camera among the Japanese Population. Nutr. J. 2021, 20, 68. [CrossRef] [PubMed]

43. Nelson, M.; Atkinson, M.; Darbyshire, S. Food Photography II: Use of Food Photographs for Estimating Portion Size and the Nutrient Content of Meals. Br. J. Nutr. 1996, 76, 31–49. [CrossRef] [PubMed]

44. Huybregts, L.; Roberfroid, D.; Lachat, C.; van Camp, J.; Kolsteren, P. Validity of Photographs for Food Portion Estimation in a Rural West African Setting. Public Health Nutr. 2008, 11, 581–587. [CrossRef]

45. Korkalo, L.; Erkkola, M.; Fidalgo, L.; Nevalainen, J.; Mutanen, M. Food Photographs in Portion Size Estimation among Adolescent Mozambican Girls. Public Health Nutr. 2013, 16, 1558–1564. [CrossRef] [PubMed]

46. Robson, P.J.; Livingstone, M.B.E. An Evaluation of Food Photographs as a Tool for Quantifying Food and Nutrient Intakes. Public Health Nutr. 2000, 3, 183–192. [CrossRef]

47. Williamson, D.A.; Allen, H.R.; Martin, P.D.; Alfonso, A.J.; Gerald, B.; Hunt, A. Comparison of Digital Photography to Weighed and Visual Estimation of Portion Sizes. J. Am. Diet. Assoc. 2003, 103, 1139–1145. [CrossRef]

48. Baranowski, T.; Baranowski, J.C.; Watson, K.B.; Martin, S.; Beltran, A.; Islam, N.; Dadabhoy, H.; Adame, S.H.; Cullen, K.; Thompson, D.; et al. Children’s Accuracy of Portion Size Estimation Using Digital Food Images: Effects of Interface Design and Size of Image on Computer Screen. Public Health Nutr. 2011, 14, 418–425. [CrossRef]

49. Timon, C.M.; Cooper, S.E.; Barker, M.E.; Astell, A.J.; Adlam, T.; Hwang, F.; Williams, E.A. A Comparison of Food Portion Size Estimation by Older Adults, Young Adults and Nutritionists. J. Nutr. Health Aging 2018, 22, 230–236. [CrossRef]

50. Ali, H.I.; Platat, C.; el Mesmoudi, N.; el Sadig, M.; Tewfik, I. Evaluation of a Photographic Food Atlas as a Tool for Quantifying Food Portion Size in the United Arab Emirates. PLoS ONE 2018, 13, e0196389. [CrossRef]

51. Ikeda, N.; Takimoto, H.; Imai, S.; Miyachi, M.; Nishi, N. Data Resource Profile: The Japan National Health and Nutrition Survey in Japan. 2019. Available online: https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/kenkou_iryou/kenkou/2019/kenkou_iroyou/kenkou/2019/kenkou_iroyou/2019/0002.html (accessed on 22 April 2022).

52. Suga, H.; Asakura, K.; Sasaki, S.; Nojima, M.; Okubo, H.; Hirota, N.; Notsu, A.; Fukui, M.; Date, C. Effect of Seasonality on the Estimated Mean Value of Nutrients and Ranking Ability of a Self-Administered Diet History Questionnaire. Nutr. J. 2014, 13, 51. [CrossRef] [PubMed]

53. Tokudome, Y.; Imaeda, N.; Nagaya, T.; Ikeda, M.; Fujiwara, N.; Sato, J.; Kuriki, K.; Kikuchi, S.; Maki, S.; Tokudome, S. Daily, Weekly, Seasonal, within- and between-Individual Variation in Nutrient Intake According to Four Season Consecutive 7 Day Weighed Diet Records in Japanese Female Dietitians. J. Epidemiol. 2002, 12, 85–92. [CrossRef] [PubMed]

54. Owaki, A.; Takatsuka, N.; Kawakami, N.; Shirami, H. Seasonal Variations of Nutrient Intake Assessed by 24 Hour Recall Method. J. Nutr. Health Aging 2000, 4, 184–189. [CrossRef] [PubMed]

55. Murakami, K.; Livingstone, M.B.E.; Sasaki, S. Thirteen-Year Trends in Dietary Patterns among Japanese Adults in the National Health and Nutrition Survey in Japan. 2019. Available online: https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/kenkou_iryou/kenkou/eiyou/r1-houkoku_00002.html (accessed on 22 April 2022).

56. Robson, P.J.; Livingstone, M.B.E. An Evaluation of Food Photography as a Tool for Quantifying Food and Nutrient Intakes. Public Health Nutr. 2000, 3, 183–192. [CrossRef]

57. Williamson, D.A.; Allen, H.R.; Martin, P.D.; Alfonso, A.J.; Gerald, B.; Hunt, A. Comparison of Digital Photography to Weighed and Visual Estimation of Portion Sizes. J. Am. Diet. Assoc. 2003, 103, 1139–1145. [CrossRef]

58. Baranowski, T.; Baranowski, J.C.; Watson, K.B.; Martin, S.; Beltran, A.; Islam, N.; Dadabhoy, H.; Adame, S.H.; Cullen, K.; Thompson, D.; et al. Children’s Accuracy of Portion Size Estimation Using Digital Food Images: Effects of Interface Design and Size of Image on Computer Screen. Public Health Nutr. 2011, 14, 418–425. [CrossRef]

59. Timon, C.M.; Cooper, S.E.; Barker, M.E.; Astell, A.J.; Adlam, T.; Hwang, F.; Williams, E.A. A Comparison of Food Portion Size Estimation by Older Adults, Young Adults and Nutritionists. J. Nutr. Health Aging 2018, 22, 230–236. [CrossRef]

60. Ali, H.I.; Platat, C.; el Mesmoudi, N.; el Sadig, M.; Tewfik, I. Evaluation of a Photographic Food Atlas as a Tool for Quantifying Food Portion Size in the United Arab Emirates. PLoS ONE 2018, 13, e0196389. [CrossRef]

61. Ikeda, N.; Takimoto, H.; Imai, S.; Miyachi, M.; Nishi, N. Data Resource Profile: The Japan National Health and Nutrition Survey (NHNS). Int. J. Epidemiol. 2015, 44, 1842–1849. [CrossRef]

62. Office of Nutrition, Health Service Division, Health Service Bureau, Ministry of Health, Labour and Welfare, Japan. The National Health and Nutrition Survey in Japan. 2019. Available online: https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/kenkou_iryou/kenkou/eiyou/r1-houkoku_0002.html (accessed on 22 April 2022).

63. Suga, H.; Asakura, K.; Sasaki, S.; Nojima, M.; Okubo, H.; Hirota, N.; Notsu, A.; Fukui, M.; Date, C. Effect of Seasonality on the Estimated Mean Value of Nutrients and Ranking Ability of a Self-Administered Diet History Questionnaire. Nutr. J. 2014, 13, 51. [CrossRef] [PubMed]

64. Tokudome, Y.; Imaeda, N.; Nagaya, T.; Ikeda, M.; Fujiwara, N.; Sato, J.; Kuriki, K.; Kikuchi, S.; Maki, S.; Tokudome, S. Daily, Weekly, Seasonal, within- and between-Individual Variation in Nutrient Intake According to Four Season Consecutive 7 Day Weighed Diet Records in Japanese Female Dietitians. J. Epidemiol. 2002, 12, 85–92. [CrossRef] [PubMed]

65. Owaki, A.; Takatsuka, N.; Kawakami, N.; Shirami, H. Seasonal Variations of Nutrient Intake Assessed by 24 Hour Recall Method. Jpn. J. Nutr. Diet. 1996, 54, 11–18. [CrossRef] [PubMed]

66. Murakami, K.; Livingstone, M.B.E.; Sasaki, S. Thirteen-Year Trends in Dietary Patterns among Japanese Adults in the National Health and Nutrition Survey 2003-2015: Continuous Westernization of the Japanese Diet. Nutrients 2018, 10, 994. [CrossRef] [PubMed]

67. Foster, E.; Matthews, J.N.; Nelson, M.; Harris, J.M.; Mathers, J.C.; Adamson, A.J. Accuracy of Estimates of Food Portion Size Using Food Photographs—The Importance of Using Age-Appropriate Tools. Public Health Nutr. 2006, 9, 509–514. [CrossRef] [PubMed]

68. Subar, A.F.; Freedman, L.S.; Tooze, J.A.; Kirkpatrick, S.J.; Boushey, C.; Neuhouse, M.L.; Thompson, F.E.; Potischman, N.; Guenther, P.M.; Tarasuk, V.; et al. Addressing Current Criticism Regarding the Value of Self-Report Dietary Data. J. Nutr. 2015, 145, 2639–2645. [CrossRef] [PubMed]

69. Foster, E.; Matthews, J.N.; Nelson, M.; Harris, J.M.; Mathers, J.C.; Adamson, A.J. Accuracy of Estimates of Food Portion Size Using Food Photographs—The Importance of Using Age-Appropriate Tools. Public Health Nutr. 2006, 9, 509–514. [CrossRef] [PubMed]