Development of a Photographic Food Atlas as a Portion Size Estimation Kit for Malaysian

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Summary A photographic food atlas is a series of photographs showing different quantities of different foods. It serves as a portion size estimation aid (PSEA). In Malaysia, the existing food atlases, which display foods in exchanges and standard portion sizes, may not be representative of the actual sizes of the portions of food consumed by the local population. This paper aims to describe the development of a food atlas, namely the ‘MY Food Album’, and assess its usability as a PSEA. Thirty four participants (aged 31.6±20.9 y) served themselves, in a laboratory setting, what they considered to be typical, small, medium, and large portions of 23 amorphus food items. All food portions were weighed to obtain the mean and standard deviation of the range of food portion sizes to be displayed in the food atlas. Using standard camera and lighting settings, various local foods were photographed at an angle of 45°. A total of 393 food items were categorized into 14 food groups and presented as serial (n=101), guide (n=213) and range (n=79) photographs. The usability of MY Food Album was evaluated by six nutritionists and dietitians using an adapted questionnaire. The food atlas was perceived to be useful to aid in the quantification of food during dietary assessment. It was suggested that the function, dimension and application of fiducial markers be introduced in the food atlas to facilitate its use in size estimation. While MY Food Album was well-accepted as a PSEA, further validation is required to evaluate the effectiveness of this newly developed food atlas in portion size estimation.

Key Words photographic food atlas, portion size estimation, dietary assessment

Portion size estimation aids (PSEAs) such as household measures, food models and food photographs, have been used as visual aids to complement dietary assessment. They are commonly used to help clients or patients remember and describe the amounts of foods they had consumed in the recent past [1]. A food atlas is a set of photographs of different amount of different foods. These photographs are then usually bound together in a single volume [2]. Food atlases are helpful in improving the accuracy of food quantification during dietary interviews and records [3, 4]. Users of food atlas can select photographs from the food atlas which are most representative of the usual or actual sizes of the food portions they had consumed [5, 6].

Portion size estimation is essential when assessing food intake relative to diet recommendations, evaluating the effectiveness of dietary intervention and studying of the relationships between diet and disease. Factors pertaining to the food atlas that may influence the accuracy of portion size estimation include the number, sizes and colour of photographs [7] and the characteristics (for example the shapes and textures) of the foods being displayed [8, 9]. Characteristics of users themselves, such as age, gender, body weight and dietary habits, have also been reported to influence the accuracy of portion size estimation [10].

Several food atlases are available in Malaysia for use by adults [11, 12] and children [13, 14]. However, most of these food atlas display food in terms of exchanges and standard portion sizes and, therefore, do not represent typical food portion size as consumed by the local population. Some photographs of the food were not taken under standard lighting conditions. Inconsistency in sharpness and clarity of the photographs might also have influenced the accuracy of portion size estimation [5]. In addition, the “cup” was used as a measure to display various foods. However, the local population does not consume noodles or rice in terms of “cups”. Hence, users of these food atlases face challenges when estimating the sizes of food portions.

Two Malaysian food atlases have been documented for its validity in estimating food portions [8, 9]. However, as these two food atlases have neither been published nor made publicly available, their usability remains unknown. Therefore, this study aims to address existing limitations by developing an improved photographic food atlas and assessing its usability as a means for Malaysian adults to estimate food portion size.

MATERIALS AND METHODS

This study was conducted in three phases. The first phase aimed to determine the range of portion sizes for common Malaysian foods. The second phase aimed to...
develop a prototype of a photographic food atlas; while the third phase aimed to determine the usability of the food atlas. Ethical approval was obtained from the UKM Research Ethics Committee (NN-2018-120).

Phase I involved 34 participants (15 males and 19 females, mostly of Malay ethnicity) aged 31.6±20.9 y. The inclusion criteria were (i) to be aged between 19 to 59 y; (ii) to have Malaysian citizenship; (iii) can read and write in the Malay or English languages, and (iv) not on any special, for example, vegan diets. Written consent was obtained from all participants before data collection.

In a laboratory setting, participants were asked to serve (but no consume) 23 prepared food items in portions they would consider small, medium, large and typical. All food portions were then weighed (Tanita KD-160) to obtain mean and standard deviation for each food item to be displayed in the food atlas. Percentage of coefficient variance (CV%) was calculated using the formula CV% = Standard deviation/Mean×100.

After obtaining the means and standard deviations of the food portions served by participants, the range of food portion sizes was calculated using weight difference between –1.5 to +2.5 standard deviation (6, 15, 16). The weight of each portion was rounded to the nearest 5 g (6).

The second phase was the development of a photographic food atlas, namely, the MY Food Album. This involved: selection of types and items of foods; determination of food portion sizes to be displayed: preparation and photographing of the foods; and finally, designing the layout of the food atlas. The food types and items were selected by referring to the available local food atlases and related documents (11, 12, 14, 17, 18), current national food consumption data (19) and the researchers’ observations of the foods readily available in the market. Food images were presented in the format of serial, guide and range photographs.

Serial photographs show varying portion sizes of a specific amorphous food, for example, eight portions of white rice, ranging from 50 g to 365 g. The range of portion size for each amorphous food was determined from the mean and standard deviation for each food, as obtained in Phase I of this study (Supplemental Online Material, Table S1). Guide photographs show different types of food belonging to a category of food, for instance, the different types of kuih-muih (local sweets) available in Malaysia. Foods with different sizes, shapes or varieties were presented as range photographs (20, 21). For example, the different sizes and varieties of red apples available in a supermarket were displayed as range photographs.

Various food commonly consumed by local population were purchased from shops in the Klang Valley. These foods were photographed at a 45° angle, using standard camera and lighting settings (5, 7, 22). Before being photographed, the foods were weighed (to the nearest 1 g) using a food weighing scale (TANITA KD-160). A dessert fork and spoon (commonly used cutlery) and a black-and-white checkered card (8 cm in length×5 cm in width) were used as fiducial markers and displayed beside the food to reflect the actual size of the food portion (2, 23). Each photograph was then arranged and labelled with a unique name and code using Microsoft Publisher 2013. The food atlas was developed using expert guidelines (2, 7, 24, 25). In the process of developing MY Food Album, some local and international food atlases were also used as references (11–14, 26).

The last phase assessed the usability of the developed MY Food Album prototype. Three nutritionists and three dietitians (mean age 36.3±4.1 y) with an average of 11.2 y of professional work experience participated in the evaluation phase. They were each provided with a hard copy of the food atlas and a usability questionnaire (which they had to complete).

The 29-item questionnaire evaluated the usability of the developed prototype in four domains: ‘Content’, ‘Potrayal of Food’, ‘Layout and Typography’ and ‘Overall Suitability’. The questionnaire items were taken from several established evaluation tools (27-30) and adapted following guidelines from Nelson et al. (7) and Nelson and Haraldsdóttir (2). Usability was assessed using a four-point likert scale: ‘Totally disagreed’, ‘Disagreed’, ‘Agreed’ and ‘Totally Agreed’, and was scored from one to four, based on the level of agreement. The participants also provided suggestions for improvement through written responses in the questionnaire and face-to-face discussions.

RESULTS

Table 1 shows the mean, standard deviation and percentage of coefficient variance of each portion sizes for all food items. Compared to other foods, mee laksa (local curry noodles) and honey coated breakfast cereal produced higher %CV for typical and large portion sizes. The %CV of porridge was highest among other food items of small and medium portion sizes.

Table S1 exhibits the range of food portion sizes which was displayed in the MY Food Album. The number of portion sizes displayed in the food atlas was determined by whether the difference in portion sizes between two food portions was visible. For example, because the size difference between rice porridge weighing 95 g and 160 g was not visible in the food photographs, only four portion sizes (that is, 95 g, 225 g, 360 g and 490 g) were included in the food atlas.

MY Food Album was developed, consisting of 393 food items and 14 food groups. The photographic food atlas presented foods in the form of serial (n=101), guide (n=213) and range (n=79) photographs. The food album was divided into two volumes: Part I- Food photographs and Part II- Food weight and nutrients (Fig. 1).

Part I is intended to be used by clients or patients to identify which photograph of a specific food is closest to the food portion size of that food which they consumed in the past. Part II is a reference for healthcare professionals to obtain the weight, energy, and macronutrient content of the specific food portion size indicated by
Table 1. Mean, standard deviation (SD) and coefficient variance (CV%) of typical, small, medium and large portion sizes of foods.

<table>
<thead>
<tr>
<th>Food items</th>
<th>N</th>
<th>Typical Mean ± SD (g) CV%</th>
<th>Small Mean ± SD (g) CV%</th>
<th>Medium Mean ± SD (g) CV%</th>
<th>Large Mean ± SD (g) CV%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Honey-coated breakfast cereal</td>
<td>26</td>
<td>24.4 ±10.2a 41.8</td>
<td>15.5 ±9.8b 63.2</td>
<td>26.1 ±11.2a 42.9</td>
<td>42.9 ±19.3c 45.0</td>
</tr>
<tr>
<td>Chocolate flavored breakfast cereal</td>
<td>26</td>
<td>29.3 ±10.7a 36.5</td>
<td>13.9 ±6.5b 46.8</td>
<td>28.1 ±11.9a 42.3</td>
<td>44.5 ±19.3c 43.4</td>
</tr>
<tr>
<td>Cornflakes</td>
<td>8</td>
<td>31.1 ±13.9a 44.7</td>
<td>14.3 ±7.6b 53.1</td>
<td>27.3 ±10.1a 40.0</td>
<td>43.4 ±17.4c 40.1</td>
</tr>
<tr>
<td>White rice</td>
<td>13</td>
<td>174.7 ±68.5a 39.2</td>
<td>105.6 ±42.3b 40.1</td>
<td>170.8 ±53.7ad 31.4</td>
<td>283.7 ±84.9c 29.9</td>
</tr>
<tr>
<td>Brown rice</td>
<td>13</td>
<td>159.6 ±53.0a 33.2</td>
<td>82.7 ±27.8b 33.6</td>
<td>142.2 ±44.6b 31.4</td>
<td>210.3 ±72.8ac 34.6</td>
</tr>
<tr>
<td>Porridge</td>
<td>8</td>
<td>223.2 ±88.6a 39.7</td>
<td>110.4 ±72.8ab 65.9</td>
<td>229.9 ±110.9a 48.2</td>
<td>340.1 ±145.5ace 42.8</td>
</tr>
<tr>
<td>Yellow sticky rice</td>
<td>13</td>
<td>120.2 ±45.6a 37.9</td>
<td>60.7 ±29.1b 47.9</td>
<td>128.5 ±36.1a 28.1</td>
<td>179.8 ±51.2c 28.5</td>
</tr>
<tr>
<td>Noodles (mee)</td>
<td>13</td>
<td>115.1 ±40.6a 35.3</td>
<td>67.4 ±24.0b 35.6</td>
<td>108.6 ±33.4a 30.8</td>
<td>160.4 ±60.7ace 37.8</td>
</tr>
<tr>
<td>Mee Hoon</td>
<td>8</td>
<td>133.5 ±48.5a 36.3</td>
<td>71.6 ±22.2b 31.0</td>
<td>114.3 ±22.6a 19.4</td>
<td>174.9 ±48.0ace 27.4</td>
</tr>
<tr>
<td>Kuey teow</td>
<td>13</td>
<td>151.8 ±41.5a 27.3</td>
<td>83.7 ±28.2b 33.7</td>
<td>132.2 ±46.8ab 35.4</td>
<td>207.9 ±69.4ace 33.4</td>
</tr>
<tr>
<td>Mee laksa</td>
<td>13</td>
<td>155.5 ±81.1a 52.2</td>
<td>81.2 ±32.8ab 40.4</td>
<td>138.2 ±48.7ad 35.2</td>
<td>215.4 ±44.9ace 20.8</td>
</tr>
<tr>
<td>Spaghetti</td>
<td>8</td>
<td>131.0 ±36.7a 28.0</td>
<td>69.4 ±18.5b 26.7</td>
<td>126.4 ±34.1a 27.0</td>
<td>178.9 ±33.9ace 18.9</td>
</tr>
<tr>
<td>Macaroni</td>
<td>13</td>
<td>113.0 ±40.6a 35.9</td>
<td>67.9 ±23.3b 34.3</td>
<td>112.0 ±35.1a 31.3</td>
<td>171.9 ±51.5ace 30.0</td>
</tr>
<tr>
<td>Fried rice</td>
<td>8</td>
<td>171.1 ±77.0a 45.0</td>
<td>93.3 ±17.7ac 19.0</td>
<td>154.1 ±28.7ac 18.6</td>
<td>220.5 ±61.7ace 28.0</td>
</tr>
<tr>
<td>Fried noodles</td>
<td>13</td>
<td>145.0 ±43.0a 29.7</td>
<td>92.3 ±28.3b 30.7</td>
<td>150.7 ±46.2a 30.7</td>
<td>207.1 ±59.8ace 28.9</td>
</tr>
<tr>
<td>Fried mee hoon</td>
<td>8</td>
<td>164.1 ±42.7a 26.0</td>
<td>96.6 ±27.5b 28.5</td>
<td>167.8 ±50.1a 29.9</td>
<td>253.6 ±59.9ace 23.6</td>
</tr>
<tr>
<td>Fried kuey teow</td>
<td>13</td>
<td>193.5 ±76.7a 39.6</td>
<td>119.8 ±44.2ab 36.9</td>
<td>181.1 ±61.5ac 34.0</td>
<td>247.5 ±88.3ace 35.7</td>
</tr>
<tr>
<td>Fried spaghetti</td>
<td>13</td>
<td>148.2 ±36.3a 34.5</td>
<td>91.9 ±28.7b 31.2</td>
<td>160.8 ±52.0a 32.3</td>
<td>236.3 ±78.5ace 33.2</td>
</tr>
<tr>
<td>Fried macaroni</td>
<td>8</td>
<td>154.8 ±65.0a 42.0</td>
<td>96.5 ±38.7b 40.1</td>
<td>159.9 ±58.2a 36.4</td>
<td>233.2 ±82.4ace 35.3</td>
</tr>
<tr>
<td>Fried instant noodles</td>
<td>13</td>
<td>138.8 ±57.1a 41.1</td>
<td>94.1 ±34.8a 37.0</td>
<td>143.4 ±53.3a 37.2</td>
<td>202.3 ±72.3ab 35.7</td>
</tr>
<tr>
<td>Green leafy vegetables</td>
<td>13</td>
<td>90.2 ±42.8a 47.5</td>
<td>41.7 ±13.5b 32.4</td>
<td>84.3 ±32.1b 38.1</td>
<td>118.6 ±35.7ace 30.1</td>
</tr>
<tr>
<td>Mixed vegetables</td>
<td>13</td>
<td>128.5 ±34.9a 27.2</td>
<td>72.3 ±24.8b 34.3</td>
<td>116.7 ±20.2a 17.3</td>
<td>169.3 ±39.8ace 23.5</td>
</tr>
<tr>
<td>Bubur cha-cha</td>
<td>13</td>
<td>117.6 ±39.2a 33.3</td>
<td>69.7 ±32.7b 46.9</td>
<td>112.0 ±33.5a 29.9</td>
<td>183.5 ±64.7ace 35.3</td>
</tr>
</tbody>
</table>

*abcd* Different superscripts in a row denote significant difference between portion sizes according to post hoc test: Turkey's or Games-Howell.
their clients or patients. All content in MY Food Album was presented in both the Malay and English languages.

Table 2 shows that, of all the evaluated domains, ‘Layout and Typography’ obtained the lowest average score (3.03±0.26), while ‘Overall Suitability’ had the highest average score (3.21±0.34). Overall, average score of all the domains was 3.12±0.28. The main suggestions provided by the nutritionists and dietitians to improve the food atlas were summarised in Table 2.

**DISCUSSION**

This study described the development of MY Food Album as a photographic food atlas for Malaysians and its usability as a PSEA as evaluated by nutritionists and dietitians.
dietitians. When determining the range of portion sizes typically consumed, it was established that the average percentage of CV for white rice was 39.2%, which was much higher than previously reported. Zamaliah (9) reported CV of 23.5–29.4% (n=30), while Badari et al. (8) reported 28.9% for lunch and 24.6% for dinner (n=15). However, the CV of green leafy vegetables in this study (47.5%) was lower compared to that in Badari and colleagues’ study (54.4%, n=15) (8). This indicated that the variation of portion sizes had changed, compared to previous studies, but the direction of change depended on the food. The results reinforced the need to update information about typical portion sizes in food atlas.

The difference in %CV observed between this and earlier studies may also be caused by factors other than actual changes in portion sizes. How hungry a person is may also affect his or her sensory perceptions, which may eventually lead to an increase in size of serving and food intake (31). Other factors such as the physical and social surroundings (for example, the presence of other people), sound, temperature, smell, colour and distractions may also affect a person’s food choice and intake (32).

Therefore, the conditions of every self-serving session (for example, venue temperature, lighting, layout and cleanliness) were controlled to be consistent throughout the study. Every participant was informed to attend the session at least two hours postprandial (to be not too full) and only one participant was invited to attend a session at any one time. A researcher was on hand to provide guidance to carry out the test.

This study resulted in the production of a photographic food atlas, namely MY Food Album, which offers several advantages compared to other food atlases already available in Malaysia. First, MY Food Album is user-friendly, as it categorizes food items into food groups readily recognised by the public. This approach is different as some food atlases categorize food according to its main macronutrient content (carbohydrates, protein and fat) or food exchange systems. In addition, there are bookmark dividers for each food group to enable quick navigation and searches. Second, MY Food Album displays images of portion sizes (from small to large) to reflect typical portion sizes for foods typically consumed by Malaysians. The use of serial photographs may help to reduce food quantification errors, compared to the ‘single photograph’ or ‘standard portion size’ approaches. Finally, content in MY Food Album is displayed in two separate volumes: one for the clients or patients and the other for healthcare professionals. This food atlas can also be reproduced to assist in food recording, FFQ or to accompany other dietary assessment methods.

As shown by its high usability rating, MY Food Album was found to be well-accepted by the participating nutritionists and dietitians as a PSEA. A major suggestion to improve the food atlas relates to the need to describe function and dimensions of the displayed utensils and standard card and how to use them as size markers in the food atlas. A possible explanation may be local healthcare professionals are less familiar in the use of fiducial markers to determine portion sizes from photographs of food (23). Another suggestion was to include more food containers such as polystyrene or plastic containers to display food items as they are increasingly used for takeaway foods. These suggestions will be taken into consideration when future editions of MY Food Album are planned.

This study has several limitations. First, the portion sizes of the serial photographs used in this study was determined from a convenience sample of Malay and Chinese adults. Therefore, the range of portion sizes displayed in MY Food Album may not be representative of the populations present in Malaysia. While weighing is a more accurate method (compared to using a questionnaire or an interview) to determine portion sizes, asking the participants to serve the food without actually consuming them may not be the accurate, that is, the portion sizes of the food served may be different from the portion sizes of the food the participants would have actually consumed (13). In addition, it is not possible to include an exhaustive list of all foods consumed in Malaysia in the food atlas. However, the panel evaluation was of the opinion that the food atlas has sufficient content validity to be used as a food atlas in Malaysia.

In conclusion, this study developed a photographic food atlas which included food photograph series representing portion sizes of foods typically consumed by Malaysian adults. Positive feedback was obtained from nutritionists and dietitians regarding the use of the food atlas as a PSEA. Further validation is required to evaluate the effectiveness of using this newly developed food atlas as a PSEA.

Disclosure of state COI
The authors declare no conflict of interest.

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Supporting information
Supplemental online material is available on J-STAGE.

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