Development and Validation of a Sustainable Diet Index among Malaysian Adults: Protocol

(Pembangunan dan Kesahihan Indeks Diet Lestari di Kalangan Rakyat Malaysia Dewasa: Protokol)

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ABSTRACT

Adopting a sustainable diet is an alternative to address the pandemics of obesity, undernutrition and climate change that are threatening human health. Sustainable diet considers the health aspect as well as the environmental impact of diets. There is a scarcity of research on sustainable diet and lack validated tools for its measurement. This article aimed to describe the protocol on the development and validation of a Sustainable Diet Index (SDI) among Malaysian adults. A Sustainable Diet Index (SDI) was developed based on previous studies and available dietary guidelines on sustainable diet. Five indicators (rice, animal-based food, plant-based food, food waste and packaging) were included in the SDI. The index will be validated among Malaysian adults using mobile food record as the dietary assessment tool. The index has the potential to measure the level of healthy and sustainable diet behaviour of an individual. The use of mobile food record provides images of each eating occasion for the evaluation of serving size and the information on waste management. Health and environmental impacts from the diet can be evaluated through the integration of all indicators in the SDI. The index developed is novel and expected to provide a feasible measurement to assess the level of sustainable diet of an individual.

Keywords: Environment; health; protocol; sustainable diet index

ABSTRAK

Amalan diet lestari adalah alternatif untuk menangani pandemik keobesan, kurang nutrisi dan perubahan iklim yang mengancam kesihatan. Diet lestari merangkumi kedua-dua aspek kesihatan dan alam sekitar daripada diet. Terdapat kekurangan dalam penyelidikan mengenai diet lestari dan alatan yang sahih untuk mengukur diet lestari. Kertas ini bertujuan untuk menghuraikan protokol mengenai pembangunan dan kesahihan Indeks Diet Lestari (SDI) di kalangan rakyat Malaysia dewasa. Indeks Diet Lestari (SDI) dicipta berdasarkan kajian terdahulu serta mengambil kira garis panduan pemakanan yang merangkumi aspek diet lestari. Lima komponen (beras, makanan berasaskan haiwan, makanan berasaskan tumbuhan, sisa makanan dan pembungkusan) disertakan di dalam SDI. Indeks ini akan disahkan di kalangan rakyat Malaysia dewasa menggunakan rekod makanan mudah alih sebagai alat penilaian diet. Indeks ini mempunyai potensi untuk mengukur tahap amalan diet yang sihat dan lestari seseorang. Penggunaan rekod makanan mudah alih dapat memberi imej makanan dan minuman yang diambil untuk penilaian saiz hidangan dan pengurusan sisa. Kesan terhadap kesihatan dan alam sekitar daripada diet dapat dinilai melalui penyatuan semua komponen dalam SDI. Indeks yang telah dibangunkan ini adalah baharu dan dijangka dapat memberikan pengukuran yang mudah untuk menilai tahap diet lestari seseorang.

Kata kunci: Indeks diet lestari; kesihatan; persekitaran; protokol

INTRODUCTION

Climate change cause harmful effects to agricultural production, food security, and health (Scheelbeek et al. 2018). The agriculture and food system are also heavily affected by environmental changes causing major health implications due to the reductions in yields and alterations of the nutritional composition of crops (Tuomisto et al. 2017).

A shift to more sustainable food system would allow the prevention of infectious disease, reduce environmental footprint, and better nutrition (Canavan et al. 2017). Food system is a major contributor to global greenhouse-gas (GHG) emissions. Greenhouse gases are produced and emitted at all stages in the system, from farming to food distribution, consumption, and the disposal of waste. High fat foods such as highly processed foods and animal products, are among the most emissions-intensive (Lowe 2014).

Interventions are necessary to counter the problem and reduce GHG emission to the minimal. Recent studies showed that choosing diet that incorporates its environmental impacts can also impose health benefits. Recommendations for healthy diets are not complete if the indirect health impacts caused by environmental changes associated with food production and consumption are ignored (Tuomisto 2018). Food and Agriculture Organization (FAO) (2010) advocated sustainable diet as the ideal diet for the planet with low environmental impact without compromising the nutritional benefits for present and future generation.

However, measurements and indicators assessing the environment impacts on human health and nutrition are still ambiguous (Eggersdorfe et al. 2016). Lukas et al. (2016) reported four commonly used indicators that relates with the environmental effect of food production and consumption; i.e. the carbon footprint, land use, material footprint, and water footprint. Dong and Hauschilda (2017) highlighted three environmental indicators which were Life Cycle Analysis (LCA), planetary boundary framework (PB), and United Nation's Sustainable Development Goals (SDGs) in making the decision on sustainable consumption and production.

Life cycle assessment (LCA) addresses the environmental impacts of a product's life cycle through 'cradle to grave' concept as an ideal method to evaluate GHG emission of a food product. LCA is a widely used and standardized tool for the systematic evaluation of the environmental aspects of a food item, which cover all stages of its life cycle from production to waste. In LCA, the carbon footprint (CF) is considered as an indicator of environmental impact that reflects the impact of GHG emissions affecting climate change (Gonzalez-Garcia et al. 2018).

Data on CF of food production has been assessed through many countries in recent years. Different food groups emit different intensity of GHG. The food products from animal such as beef, poultry meat, mutton, dairy products and fish emitted more carbon dioxide, hence higher CF than the crops (Pathak et al. 2010).

A few studies explored the impact of diet to the environment by measuring the GHG emitted from the population's diet. Animal-based diet have higher GHG emission than plant-based diet (Drewnowski et al. 2015; Gonzalez-Garcia et al. 2018). Currently, there is an index on food system sustainability named the Food Sustainability Index (FSI) (BCFN 2017). The FSI was designed to assess the sustainability performance of the national food system under three pillars; sustainable agriculture, nutritional challenges, and food loss and waste. The index acted as the benchmark in monitoring the challenges encountered by the 34 countries participated in confronting the sustainability of food system. However, this index focused on the country's performance on sustainability food system, not at individual level.

There is actually a gap in available indicators to evaluate the level of individuals' action and roles in contributing to sustainability issues (Dahl 2012). Due to the unavailability of indicators of sustainability globally, the role of individuals in making change to environmental problems like climate change can be under-estimated when it is hard for the individuals to appreciate the significance of the cumulative impact from their small actions (Dahl 2012). To fill this gap, this study intends to develop a simple and measurable index to evaluate the sustainability behaviour from food consumption at individual level.

MATERIALS AND METHODS

The study will be conducted in two phases (Figure 1). Phase 1 is the development of indicators for Sustainable Diet Index (SDI) based on previous studies. Meanwhile Phase 2 involves the use of 3-days of food and beverage images in validating the index and measuring healthy, sustainable diet.

The study will be a cross-sectional study. Recruitment of 100 participants will be conducted among students and staff from University of Malaya. Hair et al. (2014) stated that the sample size of 100 provides an adequate basis for the calculation of the correlations between variables. An email invitation will be delivered to the university's official email of all staff and students from the university. Participants will be screened online to ensure the inclusion criteria is met (Malaysian, staff or students of the university and own a smartphone with an Android operating system). Potential participants will be excluded if they are following restrictive diet, pregnant or breastfeeding.

Ethics approval from the University Malaya Ethics Committee (Reference Number: UM.TNC2/UMREC - 478) was obtained before the study was conducted. Permission

from the university's Student Affair Division was also obtained before recruitment of participants.

The Malaysia Diet Quality Index has been developed and validated to assess the diet quality of Malaysian university students (Fokeena et al. 2016). The index was developed by referring to the Malaysian Dietary Guidelines and Malaysia Food Pyramid, where the participants' adherence to both references were assessed and scored. Similarly, Roy et al. (2016) also used the updated Dietary Guidelines for Australian Adults and Australian Guide to Healthy Eating to develop the Healthy Eating Index for Australian Adults (HEIFA-2013) in assessing the dietary intake among university students.

These two studies set up healthy eating index based on the available dietary guidelines in the population where the adherence to the recommendations was measured through an index which was feasible and easy. Based on this ground, the available guidelines on sustainable diet were listed and reviewed in sorting out the key points recommended for a healthy and sustainable diet practice. Food Climate Research Network (FCRN) reported that out of 83 available dietary guidelines from all over the world, only four (Brazil, Germany, Sweden and Qatar) took account on sustainability or ecological concern in the main messages (Fischer & Garnett 2016). Non-official guidelines discussing the practice of sustainable diet were also included from Sustainable Development Commission (2009), Food and Climate research Network (FCRN) (Garnett et al. 2014), Italian Barilla Center for Food and Nutrition (BCFN) (Ruini et al. 2015) and WWF-UK Livewell (Williamson 2011).

The main points highlighted in the guidelines included taking more plant-based food, consume less animal-based food, choose more oily fish and eco-labelled seafood, reduce food waste, preferred organic and fair-trade food products, choose local food, avoid excess total calorie intake, reduce unnecessary packaging and practice recycling, eating seasonally, use eco-friendly equipment in food preparation, limit processed food, choose variety of food and reduce high fat and sugary food and beverages (Table 1).

The previous definition on sustainable diet made it profound for a diet to be healthy while having low environmental impact. Health and environment will be selected as the main indicators for the index as all guidelines agreed on the inclusion of these two indicators in determining the sustainability of a diet. The sub-indicators which were mentioned more than 50% from the guidelines will be included in the SDI. The sub-indicators that fulfil the criteria are fruits and vegetables, meat, dairy and fish and food waste. Additional sub-indicators on packaging and cereal and grains food group are added to the SDI. The conceptual indicator framework of the SDI with all indicators proposed are presented in Figure 2.

Packaging is added as the sub-indicator in the index as packaging are closely related to food waste, where food packaging affect the amount of food waste generated, either through reduction (by keeping food for further consumption) or additional waste (by unnecessary wrapping) (Williams et al. 2012).

Meanwhile, rice is the staple food in Asian countries, including Malaysia and it contributes almost one-third of the daily energy intake among Malaysians (Lipoeto et al. 2013). Even though rice have lower carbon footprint than animal-based food, rice could be the largest contributor for GHG emission from a carbohydrate-rich diet like a typical Asian diet. Studies from Malaysia, China, and India have shown that rice is the major contributor for the greenhouse gas emission from diet due to its high consumption (Pathak et al. 2010; Song et al. 2015). Considering these reasons, packaging and rice are added into the sub-indicators for SDI.
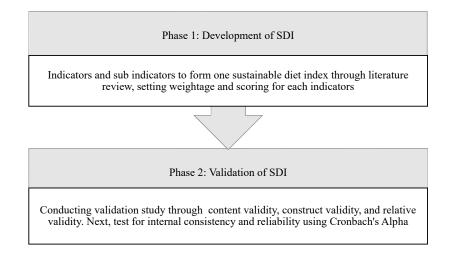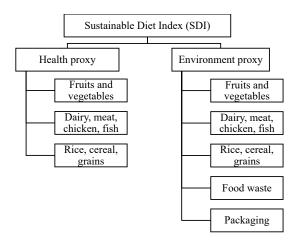

Phase 1: Development of SDI

Indicators and sub indicators to form one sustainable diet index through literature review, setting weightage and scoring for each indicators

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Phase 2: Validation of SDI

Conducting validation study through content validity, construct validity, and relative validity. Next, test for internal consistency and reliability using Cronbach's Alpha

FIGURE 1. Flowchart of the study

Sustainable Diet Index (SDI)

Health proxy
- Fruits and vegetables
- Dairy, meat, chicken, fish
- Rice, cereal, grains

Environment proxy
- Fruits and vegetables
- Dairy, meat, chicken, fish
- Rice, cereal, grains
- Food waste
- Packaging

FIGURE 2. Conceptual indicator framework for Sustainable Diet Index (SDI)

TABLE 1. Review on dietary and diet- related guidelines on sustainable diet

Available guidelines on sustainable diet	Main indicators				Sub- indicators/ Recommendations													
	Health	Environment	Social	Economy	Plant-based	animal-based	Excess energy intake	Fish intake	Food waste	packaging and recycling	eating seasonally	local food	Food preparation	Organic	Fair trade	processed food	Food diversity	Fat and sugary food
Sweden (Fogelberg 2013)	/	/			/	/		/	/	/		/	/					/
German (Oberritter et al. 2013)	/	/	/		/	/		/	/	/	/	/	/	/				
Brazil (Ministry of Health of Brazil 2015)	/	/	/		/	/				/						/		
Qatar (Seed 2015)	/	/			/	/		/				/	/		/			
Netherland (Health Council of the Netherlands 2011)	/	/			/	/	/	/	/									
Australia (Health, National and Medical Research Council 2013)	/	/					/		/	/	/							
Nordic (Fogelholm 2013)	/	/			/	/	/	/								/		
Estonia (Montagnese et al. 2015)	/	/			/						/	/		/	/		/	
SDC (Commission 2009)	/	/	/	/	/	/	/	/	/	/	/		/	/	/			/
FCRN (Garnett et al. 2014)	/	/	/	/	/	/	/	/									/	/
BCFN (Ruini et al. 2015)	/	/			/	/			/		/	/			/	/	/	
WWF-Livewell (Williamson 2011)	/	/			/	/		/	/						/	/	/	
TOTAL	12	12	4	2	11	10	5	8	7	5	5	5	4	3	5	4	4	3

The indicators for health proxy include: fruits and vegetables; dairy, meat, chicken and fish; and rice, cereal, and grains. Food waste and packaging are excluded as they do not possess health benefit rather than environmental impact. In this study, the Malaysian Dietary Guidelines (MDG) will be used as the standard for health indicators. MDG was developed for healthy dietary practices among Malaysians, which was based on dietary patterns and Recommended Nutrients Intake (RNI) for Malaysians (National Coordinating Committee on Food and Nutrition 2010). Serving size of the food intake will be compared to the recommended serving size as stated in the MDG (Table 2). Intake of food which falls within the recommended serving size will get more score than those which do not.

As example, MDG recommended 3 servings of vegetables and 2 servings of fruits intake per day for an individual (National Coordinating Committee on Food and Nutrition 2010). The intake of fruits and vegetables will be presented in serving size and kg. Hence, the total intake of fruits and vegetables will be counted by finding the difference between total serving size before and after eating. The intake of food items in serving size will be summed up for all meals in the day to obtain the total serving intake of food item per day.

Carbon footprint (CF) in kg CO_2eq per day^{-1} will be used to measure the environmental impact from consumption of different food groups. To the best of our knowledge, data on CF of food products in Malaysia is not available. Hence, data on CF for food groups available from study by Song et al. (2015) will be used. The total GHG calculation from the CF will be presented in kg CO_2 per individual through the 3-day food image capture. The GHG emission calculated per individual will then be scored accordingly.

Plate waste estimation are commonly presented as the percentage by weight of the remaining uneaten served food (Williams & Walton 2011). In that basis, all food waste will be presented in percentages. Whereas, individually packaged food will be grouped into type of packaging used (plastic or paper). Both food waste and food packaging items will be classified in accordance to their waste management (thrown away, recycled, compost, given to pet and kept being used/eaten again).

Comstock method will be adapted in order to estimate the amount of food waste produced in a mealtime. This method is commonly used in both food service and clinical setting to evaluate the percentage of food waste produced by an individual (Parent et al. 2012). Even though the original method used direct visual estimation as to record the plate waste, Parent et al. (2012) found that the digital imaging method is a reliable alternative as compare with real-time visual estimation. The presence of digital imaging or food images allows more time for the assessor to make assessment on the food waste percentage by comparing the image of the consumed meal with the reference image.

The Comstock method is a 6-point scale (0, 25, 50, 75, 90, or 100%) evaluating the portion of food waste remaining on the meal plate (Comstock et al. 1981). In order to increase the accuracy on the estimation of the waste, an additional scale point of 10% (almost no food remain) will be included in the scale (Parent et al. 2012). The total percentage of food waste will then be equally scored under the same 5 scoring scale method.

The indicators will be displayed in one level each (health and environment) as previously shown by Lukas et al. (2016). Both effect level set are then summed up and the average is obtained. The result is presented in one index. Higher index indicates better practice of sustainable and healthy diet of an individual. Formula for sustainable diet index (SDI) final calculation is as follows: -

$$Sustainable\ Diet\ Index\ (SDI) = \frac{Health\ Indicator + Environment\ Indicator}{2}$$

Construct validation using factor analysis will be conducted to confirm the indicators belong to the same group as allocated in the Phase 1 study. The reasons of applying Exploratory Factor Analysis (EFA) are: to check for calculation of the weight associated with each individual indicator, and observing the multidimensionality of the data set. The number of components extracted will be finalized based on eigenvalues value, scree plot, and factor loading. Any changes in the index scale will be done according to the data obtained from the EFA. The components extracted from EFA will then confirmed via Confirmatory Factor Analysis (CFA).

An android application (ios) named Sustainable Food Record (SFR) was developed to upload food images to be used as the dietary assessment tool for the index's validation. Participants will be required to capture images of food and drinks taken for both before and after eating occasions. The images were taken and uploaded in the SFR from two different angles (45 and 90°) on all meals taken for three days. Image capture method is an alternative to record dietary intake and food waste of an individual as compared to the traditional 24 h diet record method. Previous study with the mobile food records showed no difference between the reported energy intake and estimated energy requirement (Kerr et al. 2016).

The before and after eating images taken using the Sustainable Food Record application will allow for the assessment of food waste and packaging use, as well as the estimation of food serving and portion sizes (Harray et al. 2015). Taking the 24 h diet recall alone will provide the type and amount of food taken by the participant but would not show the food waste and packaging used. Food waste is important to assess for the impact of the whole eating period towards the environment (Panizza et al. 2017). Hence, image-based method was chosen instead of the traditional 24 h recall.

The record of the images and the additional information (waste management, place of eating and comment) will be kept in the cloud storage according to the respective user's file, recorded with date and time taken of each image (Figure 3). Additional components like 'kept to be taken later', 'recycle', 'compost', 'given to pet', 'given to other people' and 'thrown in bin' were included.

However, the mobile application will only provide the images of food items as well as waste involved during meal occasions, without the automatic estimation on the volume or weight of the food. The estimation will be manually carried out by a trained Dietitian. Participants will be advised to place a pair of spoon and fork right beside the plate to aid with the portion size and volume estimation. Besides that, Food Atlas Book (3rd Version) will be used as a reference to aid in portion size estimation (Suzana et al. 2015).

The image from the MFR application will be validated to make sure it can provide true estimation of the portion size of the food item. The food images will be relatively validated against the traditional 24 diet recall for the macro- and micronutrients content. Inter-rater reliability test will also be assessed by comparing the estimation of intake between two independent dietitians.

TABLE 2. Recommended serving size per day based on Malaysian Dietary Guideline

No	Food group	Recommended intake per day
	Fruits and vegetables	5 servings
	Legumes	½ - 2 servings
	Milk and milk products	1 - 3 servings
	Chicken, meat, egg	½ - 2 servings
	Fish	1 serving

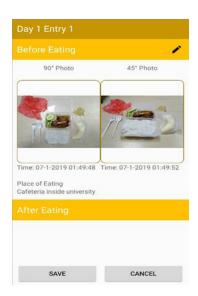(Source: National Coordinating Committee on Food and Nutrition 2010)

FIGURE 3. Example of eating occasion recorded in the
Sustainable Food Record mobile application

DISCUSSION

This protocol describes the proposed methods in developing an index incorporating two important aspects in sustainable diet's context; health and environment. The components in the index will be checked and confirmed *via* Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA). Images from the three-day diet record *via* mobile application will act as the dietary assessment tool for the SDI relative validity.

Sustainable diet is optimal for health and environment in minimising the global pandemics of obesity, under-nutrition and climate change (Willett et al. 2019). Sustainable Diet Index (SDI) was developed based on a few available guidelines which corporate sustainability or environmental aspects (Harray et al. 2015). The SDI is novel with integration of two aspects; health and environment as compared to the traditional healthy eating index. The index will provide a better and in-depth aspect of practicing healthy and sustainable diet through its five components (rice, animal-based food, plant-based food, food waste and packaging).

Study on sustainable diet in Malaysia is limited. To the best of our knowledge, there are no available guidelines or recommendations available in Malaysia that integrated both health and environmental aspects. Current Malaysian Dietary Guidelines only emphasize on health aspect through its 14 key messages in promoting healthy eating and active lifestyle (National Coordinating Committee on Food and Nutrition 2010). Sustainability should be included in the national dietary guidelines, following countries like Brazil, Germany, Sweden and Qatar (Fischer & Garnett 2016). Incorporating both health and environment aspects into formal guidelines will aid to counter the obesity, under-nutrition and climate change problems in the country.

On the other hand, mobile food record may become the latest dietary assessment tool with the availability of smartphones among the population, either manually or automatically. The before and after eating and dual angle images that need to be uploaded by the user will help the dietitian in assessing diet of the users. The mobile food record application incorporated food packaging and waste management which may not be practiced by other researchers.

However, there are some limitations in the study. Similar to other studies using mobile food record as the dietary assessment tool, the mobile food record has some restrictions. Users may provide lower image resolution or forget to take or upload images for before and after eating occasion. The uploading process of the images can also be disturbed by slow internet connection. These problems can be solved by giving thorough instructions prior to the study and sending constant reminders to the participants to take images for all food and beverages consumed.

Malaysian Dietary Guidelines were referred in developing the index, which restricted the index's usage to Malaysia population only. The use of external data on the carbon footprint of the food items is another limitation as these data are not available in Malaysia. Despite that, the index may set as the pioneer in assessing the levels of sustainable diet practice in the country. The study has completed by June 2020.

CONCLUSION

This protocol describes the development and validation process of Sustainable Diet Index (SDI) for Malaysian healthy adults. The index measures the level of sustainable eating at individual level using mobile food record. The newly developed SDI is expected to be able to assess the compliance to the recommendations for healthy eating and low environmental impact in the form of greenhouse gas emission.

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