Title: A comparison of the healthiness of packaged foods and beverages from 12 countries using the Health Star Rating nutrient profiling system, 2013-2018

Abstract

We compared the healthiness of packaged foods and beverages between selected countries using the Health Star Rating (HSR) nutrient profiling system. Packaged food and beverage data collected 2013-2018 were obtained for Australia, Canada, Chile, China, India, Hong Kong, Mexico, New Zealand, Slovenia, South Africa, the UK, and USA. Each product was assigned to a food or beverage category and mean HSR was calculated overall by category and by country. Median energy density (kJ/100g), saturated fat (g/100g), total sugars (g/100g) and sodium (mg/100g) contents were calculated. Countries were ranked by mean HSR and median nutrient levels. Mean HSR for all products (n=394,815) was 2.73 (SD 1.38) out of 5.0 (healthiest profile). The UK, USA, Australia and Canada ranked highest for overall nutrient profile (HSR 2.74-2.83) and India, Hong Kong, China and Chile ranked lowest (HSR 2.27-2.44). Countries with higher overall HSR generally ranked better with respect to nutrient levels. India ranked consistently in the least healthy third for all measures. There is considerable variability in the healthiness of packaged foods and beverages in different countries. The finding that packaged foods and beverages are less healthy in middle-income countries such as China and India suggests that nutrient profiling is an important tool to enable policymakers and industry actors to reformulate products available in the marketplace to reduce the risk of obesity and NCDs among populations.

Introduction

Diet-related chronic diseases including obesity, type 2 diabetes and cardiovascular diseases are major contributors to burden of disease in both high-income and middle-income countries.[1] Prevalence of these conditions is rising in conjunction with greater consumption of packaged and processed foods.[2] Processed food and beverage products contribute more than two thirds of dietary energy and other nutrients consumed in high-income countries,[3] and consumption of such foods is rapidly increasing in low- and middle-income countries.[4,5] Compared to unpackaged products, packaged foods tend to be higher in nutrients of concern such as added sugars, sodium, saturated fat, and trans-fat.[2] Improving the healthiness of packaged foods and beverages would likely make a significant contribution to reducing the burden of obesity and diet-related disease at both a national and a global level.[6]

Nutrient profiling is the science of classifying or ranking foods and beverages according to their nutritional composition for reasons related to preventing disease and promoting health,[7] and provides a means of evaluating the healthiness of foods and beverages. A large number of nutrient profiling models have been developed by academics, governments, non-governmental organizations and the food industry for applications such as the regulation of marketing of foods to children, front-of-pack nutrition labelling, and to underpin health and nutrition claims on product labels.[8] Many nutrient profiling models share common features and many are simply extensions or variants of prior models.[9] Nutrient profiling was designed to characterize individual foods, not diets, but nutrient profile models are commonly used to underpin policies designed to improve the overall nutritional quality of the food supply.[10] Nutrient profiling is recognized by the World Health Organization (WHO) as a helpful method to use in conjunction with other interventions aimed at improving the overall nutritional quality of diets.[9]

There is no international consensus on the superiority of one particular nutrient profiling model. The latest WHO catalogue lists more than 65 current nutrient profiling models and a more recent literature review indicated that 78 models have been released in the past 10 years.[9] These include industry-led schemes such as the Choices International's Programme,[11] government-endorsed schemes such as the UK's multiple traffic light labeling criteria[12] and France's Nutri-Score[13] as well as nutrient profiling models developed for internal use by food and beverage manufacturers. Another use of nutrient profiling is to determine which foods are eligible to make a health or nutrition claim on product packaging, for example, the Nutrient Profiling Scoring Criterion developed by Food Standards Australia New Zealand.[14]

One of the nutrient profile models most widely used in the current academic literature to evaluate the healthiness of packaged food and beverage products is the Australasian Health Star Rating (HSR) system.[15-19] The HSR is a voluntary interpretive front-of-pack nutrition labelling system in place since 2014, which is designed to assist consumers in making healthier choices and to stimulate the food industry to reformulate their products to make them healthier.[20] The underlying nutrient profile model is based upon the widely used United Kingdom Ofcom model and assesses nutrients of concern (as the densities of energy, sodium, total sugars and saturated fat) and positive nutrients (as the densities of fruit and vegetable content, protein, fibre and in some cases, calcium).[21] The system scores products based on their nutritional composition per 100g or 100mL. These HSR scores are then converted to a 'Health Star Rating' from ½ (least healthy) to 5 (most healthy) stars in ½ star increments.[22] Development of the HSR was led by the Australian government in collaboration with industry, public health and consumer groups.[23]

Since the HSR system was developed specifically to rank packaged foods and beverages according to their nutritional composition, is closely related to other widely accepted models and provides a continuous ranking of products (from 1/2 to 5 stars), it is well suited to a

comparative analysis of packaged foods and beverages available in different countries. Our objective was to use the HSR nutrient profiling scheme to examine the overall healthiness of national packaged food and beverage supplies and the healthiness of packaged food and beverage categories available in a selection of high and middle-income countries across the globe.

Methods

This study was a cross-sectional comparison of the nutritional quality of packaged foods and beverages from 12 countries. Data included in the analysis were collected between 2013 and 2018. Ethics approval was not required as no human or animal subjects were involved in this project.

Countries and products included

Countries included in the analysis are those participating in The International Network for Food and Obesity/non-communicable diseases Research, Monitoring and Action Support (INFORMAS) that are able to contribute packaged food composition data. INFORMAS is a global network of public interest organizations and researchers that aims to monitor, benchmark and support public and private sector actions to create healthy food environments and reduce obesity, non-communicable diseases and their related inequalities.[24] INFORMAS includes a food composition module,[25] led by The George Institute for Global Health, which specifies a methodology for the collection and comparison of food composition data.[26]

The George Institute's global food composition database contains regularly updated nutritional information for >400,000 packaged food and beverage products collected via supermarket surveys and through crowd-sourcing of data from the FoodSwitch smartphone application in six countries (Australia, China, India, New Zealand, South Africa and the UK) and one jurisdiction (Hong Kong).[26] For clarity to the readers of this manuscript, Hong Kong is referred to as a country rather than a jurisdiction. For other countries involved in INFORMAS for which The George Institute does not hold food composition data, we reached out to local database compilers to request data for this project. **Supplementary Table 1** outlines the data collection methodology for each of the included countries.

Food composition data

The food composition data required for these analyses were energy density (kilojoules (kJ)/100g); saturated fat content (g/100g); total sugars content (g/100g); sodium content (mg/100g); fiber content (g/100g); and percent fruit, vegetable, nut and legume (FVNL%) content. FVNL% values were not recorded on the labels for many products so proxy values were derived using information from the ingredient lists and/or known values for similar food products. Fiber content was likewise unavailable for some products and a comparable estimation method was used. Methods for FVNL% and fiber estimations have been published previously.[26] Wherever possible, proxy values were imputed from similar foods in the same country but if no such data were available then the proxy values of similar Australian food were used for analysis. Proxies were used only where information was available for at least two of four key nutrients (saturated fat, sugars, sodium, and protein) required in the HSR algorithm. If three or more of these nutrient values were missing the product was excluded from the analysis. Plain packaged water (whether still or carbonated) was assigned a HSR rating of 5.0, consistent with the HSR Guidelines.[22]

Food categorization

Foods were classified into 14 major food and beverage categories (**Supplementary Table 2**).[27] The major food categories *alcohol, herbs, spices, vitamins and supplements* were excluded from the analysis as these are not required to display a nutrition label in most countries. Similarly, *baby and infant foods* and *foods for specific dietary use* were excluded as the HSR guidance specifies that the system is not appropriate for these foods.[22] Products were also excluded from analysis if there were potential data errors identified, if they were duplicate products (i.e. the same product in different package sizes), or if they were salt or

salt substitute products. Duplicate products were removed by matching product name and levels of key nutrients (energy, protein, total fat, saturated fat, sodium and sugar).

Outcomes

The primary outcome was the HSR estimated according to methods established by the governments of Australia and New Zealand.[22] The HSR system requires products to be placed into one of six categories; (Category 1: beverages other than dairy beverages; Category 1D: dairy beverages; Category 2: all foods other than those included in Category 1, 1D, 2D, 3 or 3D; Category 2D: dairy foods other than those included in Category 1D or 3D; Category 3: oils and spreads; Category 3D: cheese and packaged cheese). The appropriate HSR category was determined on the basis of both the product name and the ingredients list. The HSR was calculated by (1) assigning baseline points for energy, saturated fat, total sugars and sodium content per 100g; (2) awarding modifying points for FVNL content, protein and fibre where applicable; (3) calculating an overall score by subtracting modifying points from baseline points, with a lower score reflecting a more nutritious food product; and (4) assigning an HSR (from 0.5 to 5.0 stars in half-star increments) according to the overall score using the defined scoring matrix. **Supplementary Figure 1** outlines an example of an HSR calculation. Secondary outcomes were energy density (kJ/100g), saturated fat (g/100g), total sugars (g/100g) and sodium (mg/100g).

Statistical analysis

Graphical representations of the data were inspected to assess the distributions of HSRs and nutrient levels. The mean HSR was calculated overall for each country and each major food and beverage category. Although HSR is an ordinal scale, mean values were calculated to

two decimal places in order to maximize discrimination of rankings between countries and categories. As nutrient data were not normally distributed, the median (IQR) of energy, saturated fat, total sugars and sodium content was calculated for each country's products overall and for each major food and beverage category. Countries were ranked into tertiles (upper third, middle third, and lowest third) according to mean HSR and median content of nutrients of concern, and heat maps were created to provide a visual representation of the healthiness of national packaged food supplies. No formal statistical tests were undertaken since the number of potential comparisons was very large and there was no clear mechanism by which the multiple possible dimensions of testing for differences could be represented. All analyses were performed using SAS Enterprise 7.15 (USA, 2017).

Results

A total of 592,635 products were available in datasets from 12 countries, of which 394,815 (67%) were included in this analysis. 197,820 (33%) products were removed because: data on multiple nutrients required for the calculation of the HSR were missing or were not available in the required format (n=115,772, 20%), the product was in an excluded category (n=67,309, 11%), or product was a duplicate (n=14,739, 2%). A total of 44,953 (11%) of products required imputation for one or more nutrients. The total number of products per country ranged from 7,191 for Chile to 162,297 for the USA (**Table 1**). The number of products per category ranged from 1,009 in *eggs* to 58,466 in *fruit, vegetables, nuts and legumes.* Differences in product numbers by country were mainly due to different methods used for data collection and total years of data collection (**Supplementary Table 1)**.

The mean HSR for all packaged products was 2.73 (SD 1.4) from a possible maximum of 5.00 stars. Ratings varied by category and *fruit, vegetables, nuts and legumes* and *eggs* had the highest mean HSR (3.63 and 3.76 respectively), followed by *seafood* (3.50). *Confectionery* had the lowest HSR of all categories examined (1.23) followed by *sugars, honey and related products* (1.39) (**Figure 1**). There was considerable heterogeneity in the healthiness of food and beverage categories by country. No country consistently ranked in the upper, middle or lower third of HSR rankings for all categories. However, countries such as Australia, New Zealand and South Africa had a relatively small number of categories in the lowest (least healthy) third of HSRs (two from a total of 14). In contrast, Hong Kong, India, Chile and China had six or more of their food and beverage categories ranked in the lowest third.

Canada, the UK, Australia and the USA had the highest ranked mean HSR for all foods and beverages combined (2.74 to 2.83) and Hong Kong, Chile, India and China had the lowest (2.27 to 2.44) (Figure 2). HSR rankings differed when foods and beverages were separated out, with some countries performing well for one and less well for the other, e.g. China ranked amongst the best performing countries for beverages (HSR 2.90) but amongst the worst for food (HSR 2.37). By contrast, South Africa's HSR for beverages (1.92) was ranked considerably lower than its HSR for foods (2.87).

There was also considerable variation in the ranking of levels of nutrients of concern between countries. Whilst countries with higher overall HSR tended to also rank better with respect to nutrient content of their foods and beverages, there were exceptions. The sodium content of foods, in particular, was not consistently related to HSR ranking. Canadian and USA products, for example, were among the highest third of median sodium content of all countries (333mg/100g and 304mg/100g respectfully) despite sitting among the highest third of mean HSR (2.74 and 2.82 respectfully). India was consistently ranked towards the bottom for all measures of nutritional quality (Figure 2).

Nutrient levels in packaged foods

Sodium

Canadian packaged foods and beverages had the highest median sodium content (291mg/100g), followed by the USA (279mg/100g). Slovenian products had the lowest median sodium content (80mg/100g) followed by Chile (140mg/100g). Overall *meat and meat alternatives* was the food group with the highest median sodium content (667mg/100g)

followed by *snack foods* (602mg/100g) and *sauces, dressings, spreads and condiments* (537mg/100g) (**Supplementary Figure 2**). *Edible oils* had the lowest median sodium content (0mg/100g) followed by *beverages* (10mg/100g).

Saturated fat

Chinese packaged foods and beverages had the highest median saturated fat content (3.4g/100g). Canada had the lowest median saturated fat content (1.0g/100g) followed by Mexico (1.1g/100g). Overall *edible oils* was the food group with the highest median saturated fat content (14.3g/100g; **Supplementary Figure 2**) followed by *confectionery* (10.7g/100g). *Beverages* and *sugars, honey and related products* had the lowest median saturated fat content (0.0g/100g), followed closely by *fruit, vegetables, nuts and legumes* with 0.1g/100g.

Total sugars

Chinese packaged foods and beverages had the highest median total sugar content (8.3g/100g), followed by India (7.3g/100g). UK foods had the lowest median sugar content (3.8g/100g) followed by Canada (4.6g/100g) and Slovenia (4.6g/100g). Overall *sugars, honey and related products* was the category with the highest median total sugar content (76.4g/100g; **Supplementary Figure 2**) followed by *confectionery* (50.6g/100g) and *bread and bakery products* (20.0g/100g). *Edible oils, seafood and seafood products* and *eggs* had the lowest median total sugar content (0.0, 0.3 and 0.3g/100g respectively).

Energy

Indian packaged foods and beverages had the highest median energy content (1515kJ/100g), followed by China (1461kJ/100g). South African products had the lowest median energy content (1044kJ/100g) followed by the UK (985kJ/100g). Overall *edible oils* was the category with the highest median energy content (3389kJ/100g; **Supplementary Figure 2**)

followed by *snack foods* (2075kJ/100g) and *confectionery* (1999kJ/100g). *Beverages* had the lowest median energy content (182kJ/100g) followed by *eggs* (596kJ/100g).

Discussion

We observed clear differences in the rankings of the mean nutrient profile of packaged food and beverage products between the 12 countries studied, as well as substantial variation in rankings of median levels of nutrients of concern such as sodium, saturated fat and total sugars. Overall, packaged foods and beverages in the UK, USA, Australia and Canada ranked healthiest (mean HSR: 2.74 to 2.83 from a possible maximum of 5.00), and Indian, Hong Kong, Chinese, and Chilean foods ranked least healthy (mean HSR: 2.27 to 2.44). Chinese and Indian packaged foods and beverages also had the highest levels of saturated fat, total sugars, and energy density. This is in line with previous research highlighting the generally unhealthy nature of packaged food and beverage products sold by the largest 11 major food companies in India (with a mean HSR of <2.0).[19] Levels of nutrients of concern have also previously been shown to be higher in foods in China compared to Western countries.[28] A recent report compared the healthiness of foods provided by nine of the world's largest food and beverage manufacturers across countries. That report identified that food sold by these companies in countries of high-income such as the UK and Australia had overall higher mean HSRs than those sold in lower-income countries such as India and China.[29] Many of the world's large food and beverage manufacturers have signed up to the International Food and Beverage Alliance, and have made pledges to reduce levels of nutrients of concern such as sodium, saturated fat and sugar[30] and these findings identify some immediate opportunities for action.[29]

The observation that packaged food and beverage products available for consumer purchases in middle-income countries such as China and India were less healthy than those in high-

income countries such as Canada, UK, Australia and UK is a significant cause for concern. India and China are experiencing a "nutrition transition", with national nutrition surveys from the past few decades showing consumption patterns switching from traditional diets based upon fruits, vegetables, unprocessed cereals and legumes to diets that are increasingly dominated by highly processed packaged food and beverage products.[31] China is now one of the largest consumers of pre-packaged foods worldwide with sales of pre-packaged foods increasing by 55% between 2003 and 2009.[32] Increases in the consumption of packaged foods and beverages are driving a double burden of diet-related disease (i.e. both undernutrition and overnutrition) in many low- and middle-income countries.[33] Compared to lower income countries, high-income countries may have a greater consumer demand for healthier foods, more policies and programmes in place to create a healthier food supply, and more food industry action to provide healthier products.[34] Despite this, we observed that the US and Canada had the highest mean sodium content of all 12 countries examined. This finding is likely due to the fact that these countries have some of the highest consumptions of processed foods and beverages in the world. Previous studies have also shown that sodium levels in US and Canadian products are higher than other countries.[35,36]

From a food category perspective, large differences in both mean HSR ranking and median levels of nutrients of concern were observed. Some results were not surprising, such as *fruit, vegetables, nuts and legumes* and *eggs* being the categories with the highest mean HSR (3.76 and 3.63 respectfully) and *confectionery* the lowest (1.23). However, results showed that there were marked differences between countries in the healthiness of the same major food categories. In India, for example, *fruit, vegetables, nuts and legume* products had a mean HSR of 2.94, while the same category in Mexico had a mean HSR of 3.97. Similarly, *meat and meat alternative* products in China had a mean HSR of 1.89 compared to 3.35 for India. These differences may reflect variation in national product portfolios (i.e. the ratio of

different types of products available) as well as differences in the average composition of the same types of products. Systematic differences between high- and middle-income countries may be attributable to a lack of capacity for implementation and enforcement of national policies, as well as differences in food labelling requirements and enforcement of food labelling.[37] Although a number of middle income countries have national policies that have now been implemented relating to the healthiness of the food supply (for example, South Africa became the first country in the world to mandate the levels of salt in packaged foods), there is not yet sufficient evidence to show that such policies have resulted in a healthier food supply overall.

A key strength of this study was the inclusion of a large number of food and beverage products from multiple countries, and the efforts taken to achieve a standardized approach to clean and process the data.[25] However, there were differences in the methods used to collect the data between some countries – for some data were obtained via store surveys undertaken in one specific year, for others data collection surveys spanned several years, and several the survey data were supplemented by crowdsourced data. The inclusion of data from multiple time-points, different seasons and the addition of crowdsourced data should have provided a more generalizable estimate of the average healthiness of the food supply in each country over the study time period. However, the different methodologies used for data collection mean that comparisons between countries may be influenced by the methodologies employed as well as real differences in the healthiness of the food and beverage products available. Importantly, whether data were obtained from surveys or crowdsourced, the checking and processing techniques applied to the nutrient data were the same because the raw data is drawn from uploaded images in both cases. Data are unlikely to be complete for any country and the extent to which data are representative will vary between countries. The different numbers of products included for different countries reflect both the range of products in a

country and the sizes of the surveys done in each. The nutrition data included in the analyses were extracted from product labels (details in Supplementary Table 1) and it is possible that the true composition of some products differs from the values found on labels. Prior studies have suggested random but not systematic differences between label data and direct testing of composition though such validation data are limited in geographic scope.[38] The use of proxy values for FVNL%, fibre and other missing nutrients for some products may have resulted in inaccurate HSR estimations, particularly for countries such as India and China where a larger amount of imputation was required. In general this would have decreased the variability of the estimated nutrient profiles for products in a given food category. A further limitation is a lack of market share data, which would help to quantify the contribution of the products to overall household food purchases and population diets. Future research in this area would benefit from the addition of sales data to determine how frequently healthier compared to less healthy foods are purchased and their likely contribution to national diets.[20,39]

Conclusion

These analyses demonstrate that there is considerable variability in the healthiness of packaged food and beverages across countries. The finding that packaged foods and beverages are consistently less healthy in countries such as China and India compared with higher income countries is a serious cause for concern. Unprecedented availability and aggressive marketing of packaged food and beverage products will be a key driver of unhealthy diets around the world,[40] and these data highlight the need for continuous monitoring and reporting of the healthiness of products across diverse countries. Nutrient profiling is an important tool that can help define and monitor policy actions to improve the healthfulness of products in the marketplace and reduce population risks of obesity and non-communicable disease risks.

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Table 1: Number of products in each major packaged food and beverage category by country

Figure 1: Heat map of nutrient profile (mean Health Star Rating – HSR) of major food categories by country

For each food category, countries were ranked as follows:

- Upper third Health Star Rating (HSR) = green
- Middle third HSR = amber
- Bottom third HSR = red

Figure 2: Heat map of nutrient profile (mean Health Star Rating – HSR) and nutritional composition (median) by country for all foods and beverages combined, separately for foods and separately for beverages

For HSR and each nutrient:

- Upper third mean Health Star Rating (HSR)/upper third median nutrient content = green
- Middle third mean Health Star Rating (HSR)/ upper third median nutrient content = amber
- Bottom third mean Health Star Rating (HSR)/ upper third median nutrient content = red

Foods and beverages were ranked separately

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