Mal J Nutr 25(1): 171-184, 2019

# Energy density of ethnic cuisines in Singaporean hawker centres: a comparative study of Chinese, Malay and Indian foods

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## ABSTRACT

**Introduction:** A major focus in the prevention and management of obesity has been in the self-monitoring of foods consumed to reduce total energy intake. The present study used a novel instrument called the Calorie Answer™ to measure the energy content of various local foods in Singapore. The study aimed to build a database on energy density of commonly consumed Chinese, Malay and Indian foods to facilitate appropriate food choices by the consumer. **Methods:** The first part consisted of measuring the energy density of 15 popular local foods purchased from 8 different hawker centres. In the second part, 46 additional local foods were analysed, again using the Calorie Answer™ instrument. **Results:** Despite the different locations from which the foods were purchased, the energy content of the same foods was remarkably similar with a coefficient of variation (CV) of $\leq$15% for all foods. There was a higher average energy density of Indian foods compared to Chinese and Malay foods (Welch test, $p$=0.027). **Conclusion:** Our results suggest that the energy density of commonly consumed foods from different locations was remarkably similar. The average energy density of Indian foods was significantly higher than that of Chinese and Malay. Knowledge of the energy density of foods is essential information that is needed in the battle against being overweight and obesity. The application of the Calorie Answer™ may be used as a means to collate data on the energy density of foods consumed in other countries in the ASEAN region.

**Keywords:** Energy density, calories, food intake, variability, Singapore

## INTRODUCTION

With rapid urbanisation, economic growth and advancement in technology, there has been a dramatic increase in consumption of animal fats, refined grains, sugar sweetened foods and a concomitant decline in physical activity (Malik, Willett & Hu, 2013). This is particularly evident in developed countries such as Singapore where the prevalence of obesity has been consistently rising (Yoon *et al.*, 2006). The aetiology of obesity is due to being in a state of positive energy balance. Energy

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doi: https://doi.org/10.31246/mjn-2018-0113.

balance may be defined as the difference between energy intake and energy expenditure. Obesity is known to be one of the major preventable risk factors that drive the epidemic of diabetes and cardiovascular diseases (CVDs) (Garrow, 1992; Kim, Després & Koh, 2016).

A major focus in the prevention and management of obesity has been in the self-monitoring of foods consumed, in order to reduce total energy intake (Burke, Wang & Sevick, 2011; Foster, Makris & Bailer, 2005; Wadden & Butryn, 2003). A significant nutritional challenge has been to use the best method to measure and quantitate what we eat in free-living populations. Among the several methods used to estimate energy intake include duplicate analysis, weighed food intake, food diary, diet record and food frequency questionnaires (Kroke *et al.*, 1999). Apart from the duplicate analysis method, all other methods necessitate the use of food composition tables (FCT) to transform the estimated weight of foods consumed into energy values.

In many regions of the world, the estimation of energy intake is based on the measurement of the amount of food that is eaten, in combination with the use of FCT. The earliest example of such table is the FCT developed by McCance and Widdowson in 1939 (Institute of Food Research & Public Health England, 2014), that has been extensively used in UK, Europe and worldwide. In Singapore, the FCT developed in 2003 by Health Promotion Board remains the most popular table in use (Health Promotion Board, 2011). At the individual level, the application of FCT is limited by the following factors: (a) the lack of data on energy/nutrient values of several commonly consumed foods; (b) a paucity of country-specific foods and recipes reported in the FCT; (c) that FCT does not reflect contemporary food products and food processing practices; (d) the perception that FCT may lead to over/under estimation of certain nutrients (Slimani *et al.*, 2007; Speek, Speek-Saichua & Schreurs, 1991; Truswell *et al.*, 1991).

Singapore has a multi-racial cosmopolitan society consisting of three major ethnic groups, namely, the Chinese, Malays and Indians who co-exist in harmony. In Singapore, as in many regions in Southeast Asia, street foods and foods prepared by small enterprises (also known as hawker centres) are major sites for the community consumption of breakfast, lunch and dinner. According to the National Nutrition Survey Singapore (2010), the proportion of Singaporeans visiting hawker centres remains high, at approximately 4-7 visits per week. This has increased from 47.8% in 2004 to 60.1% in 2010 (Health Promotion Board, 2010; Shandwick, 2014). The increasing pattern of eating at hawker centres has generated considerable interest amongst Singaporeans to know the energy density (kcal or kJ/100g) of locally available foods. This awareness may enable consumers to reduce the risk of overconsumption of energy-dense foods.

There is limited data on the caloric content of locally available foods. Most data were gathered several years ago using a combination of bomb calorimetry and Atwater Conversion Factors (Health Promotion Board, 2017). More recently, the energy content of 105 local and composite foods was reported (Lau *et al.*, 2016). The study used a novel, rapid, reproducible and cost-efficient instrument called the Calorie Answer™ to measure the energy content of various foods. This method has been validated in a range of foods (Lau *et al.*, 2016).

In the first part of our study, the objective was to determine the consistency (or otherwise) of the calorie content of 15 commonly consumed hawker foods sourced from eight regionally diverse locations within Singapore. In the second part, we further analysed 46 additional local foods in order to build up a database that could be used with confidence by the food consumers to facilitate appropriate food choices. The choice of foods analysed was based on the commonly consumed foods in each of the Chinese, Malay or Indian communities.

## MATERIALS AND METHODS

### Samples and sample preparation

In the first part of the study, 15 popular and commonly consumed local foods were purchased from eight different hawker centres and food courts in Singapore. The choice of foods selected was based on 1027 interviews/questionnaires by local Singaporeans in a GUSTO cohort study (Chen *et al.*, 2014) and an online food guide for Singapore (Wiens, 2019). The foods were selected from four regions of Singapore, North of the island – Ang Mo Kio & Seng Kang, East of the island – Parkway Parade & Simei, West of the island – Clementi & Jurong and the Central – City Hall & Tiong Bahru (Figure 1). For the second part of the study, a total of 46 foods (16 Chinese, 13 Malay and 17 Indian foods) were purchased from random hawker centres and food courts in Singapore. The descriptions of these foods obtained for this study are presented in Table 1. All foods were purchased within a week and analysed within two days of purchase.

The food samples were homogenised with a homogeniser (Blixer® 6 V.V., Robot-coupe, France) to obtain a smooth and consistent texture. All samples were allowed to equilibrate to room temperature (20–25°C) and analysed using the procedure and techniques described previously (Lau *et al.*, 2016).

### Near-infrared (NIR) spectroscopy and analysis (Calorie Answer™)

The near-infrared (NIR) spectra of the homogenised samples were obtained using the Calorie Answer™ instrument (CA-HM, JWP, Japan) over a wavelength


**Figure 1.** Map of Singapore showing locations of foods purchased for analysis

**Table 1.** Description of local foods

| *Local Foods* | *Description* |
|---|---|
| *Char kway teow* | Rice noodles, stir fried in sweet sauce with cockles and Chinese sausage |
| Fried carrot cake | Fried Chinese radish cake made with rice flour and eggs |
| Chicken rice | Roasted chicken with skin, served with flavoured rice and chilli sauce |
| Fried oyster omelette | Stir fried eggs with oyster and tapioca flour |
| *Kaya* butter toast | Toasted bread with *kaya* (coconut, egg jam) and filling |
| *Popiah* | Radish, eggs, Chinese dried sausage and sweet black sauce wrapped in a flour-based skin |
| Chicken biryani | Rice cooked with ghee and spices, served with spicy chicken |
| *Ban mian* | Flat handmade noodles served in anchovy soup with egg, anchovies, minced pork meat and green vegetables |
| *Laksa* | Thick rice vermicelli served with thick coconut milk gravy with *tau-pok* (fried soya bean curd) and fish-cake |
| *Mee rebus* | Thick yellow egg noodles served in thick spicy gravy together with hard-boiled egg |
| Ba chor mee (Minced pork noodle) | Egg noodles with black mushroom and minced pork served with chili sauce |
| *Roti prata* (Plain) | Thick, flat, round dough made with wheat flour, sugar, salt and water, fried with ghee |
| *Wanton mee* | Boiled minced pork dumpling served with egg noodles, sliced *char siew* (roast pork), *chye sim* (mustard leaves) and gravy |
| *Rojak* | Chinese salad mixed with cucumber, pineapples, apples, *tau-pok* (fried soya bean curd) drizzled with a sweet and sour sauce containing prawn paste, sugar, lime and peanuts |
| Economic bee-hoon | Fried rice noodles with fried egg, luncheon meat and cabbage |
| Prawn noodle soup | Noodles with prawns and beansprouts in soup |
| Chee cheong fun (with sauce) | Rice noodle with sweet dark colour sauce |
| Lor Mee | Yellow noodles with beansprouts, egg and pork in thick dark gravy |
| Char siew wanton noodle | Boiled wheat noodles with sliced barbecued pork and minced pork dumpling |
| Steamed chicken noodle | Boiled wheat noodles with steamed shredded chicken breast |
| Hokkien mee (black sauce) | Braised yellow noodles in dark, fragrant sauce with pork, squid, fish cake and cabbage |
| Roasted duck rice | Roasted duck meat served with white rice |
| Sliced fish hor fun | Flat rice noodles with thinly sliced fish and vegetables served in thick sauce |
| Roasted chicken rice | Roasted chicken served with chicken flavoured rice |
| Roasted pork rice | Roasted pork served with white rice |
| Soya sauce chicken noodles | Thin wheat noodles with soy sauce with chicken and preserved vegetables |

| *Local Foods* | *Description* |
|---|---|
| Claypot rice | Rice with black sauce, chicken and mixed vegetables steamed in a Claypot |
| Fan choy | Rice steamed together with barbecued pork, hard-boiled egg and stewed mushroom |
| Rice dumpling with meat filling (Nyona style) | Traditional Chinese rice dish made from glutinous rice stuff with marinated pork, candied winter melon and steamed mushrooms |
| Char siew pau | Chinese barbequed pork bun |
| Kentang ball soup with rice cube | Lightly flavoured soup with onions, cucumbers and fried potato balls stuffed with minced beef |
| Lontong goreng | Rice cakes cut into cubes and stir fried with egg and meat |
| Mee soto | Thick egg noodle soup with Indonesian spicy chicken broth |
| Lontong | Rice cake in the form of a cylinder wrapped in banana leaves, cut into bite-sized pieces served in coconut milk soup with shredded tempeh, tofu, long beans and hard-boiled egg |
| Nasi goreng | Indonesian stir-fried rice with meat and vegetables |
| Mee Bakso | Meatball soup served with yellow egg noodles and rice vermicelli |
| Mee Bundung | Noodles, egg, shrimp, chicken, fish cakes and vegetables served in a soup made with chili, onion, spices, shrimp paste and dried shrimp |
| Mee Siam | Rice vermicelli, hard-boiled egg, with a sweet and tart gravy |
| Gado gado | Indonesian salad with blanched vegetables, hard-boiled eggs, boiled potatoes, fried bean curd and tempeh, and rice cake (wrapped in banana leaf) served with peanut sauce dressing |
| Mee Goreng | Spicy fried yellow egg noodle coated in a thickened sweet and spicy sauce, tossed with fried bean curd cubes, tiger prawns, tomato wedges, leafy vegetable, bean sprout and green onions |
| Grilled fish with rice | Charcoal grilled sambal belacan fish with sliced shallots wrapped in banana leaves served with white rice |
| Nasi lemak with chicken wing and egg | Rice dish cooked in coconut milk and pandan leaf served with chicken wing, egg and sambal chili |
| Ayam Penyet with rice (grilled) | Grilled chicken thigh with sambal, cucumber slices, fried bean curd and tempeh served with white rice |
| Putu mayam | Steamed rice noodle |
| Idli | Steamed savoury rice cakes |
| Vegetable briyani | Basmati rice flavoured with spices and served with vegetables |
| Thosai masala | South Indian snack made from fermented pulses |
| Makhani dal | Whole black lentils and red kidney beans cooked in butter and cream |
| Mutton briyani | Basmati rice flavoured with spices and served with mutton |
| Chicken masala | Baked chicken marinated in coconut cream, spices and yoghurt |
| Fish tikka | Fish marinated in spice mix and grilled in oven or tandoor |
| Mutton vindaloo | Lamb curry cooked in wine, vinegar and garlic |

| *Local Foods* | *Description* |
|---|---|
| Mee goreng | Spicy stir fried egg noodle |
| Roti john | French loaf fried with minced mutton, sliced onions and egg |
| Thosai | Thin pancake made from fermented pulses and rice flour |
| Onion prata | Thick, flat, round dough made with wheat flour, sugar, salt and water, fried with ghee and onion |
| Egg prata | Thick, flat, round dough made with wheat flour, sugar, salt and water, fried with ghee and egg |
| Chapati | Whole wheat flour mixed with water and oil |

range from 1100 – 2200 nm with a resolution of 7.5 nm and a data interval of 2.0 nm. The main components of the instrument were as follows: a halogen lamp as radiation source; an acousto-optic tunable filter as wavelength selector, and light receiving sensors as light detectors. The reflectance mode was used for the solid samples and reference reflectance data was obtained with a calcium carbonate filled cell. Triplicates of each sample were scanned in cylindrical sample cells (internal diameter = 50 mm, depth = 10 mm for solid sample holders). The inbuilt computer software (CA-HM Measurement Application Software, JWP, Japan) was set so that each triplicate portion was scanned ten times, which were then averaged to give a mean spectrum for improved accuracy. The data were transformed into log 1/R and energy content for each sample was then calculated in accordance with regression expressions pre-programmed in the software. The analysis time for each measurement (including time for calibration) was about 5 minutes. The procedure of Lau *et al.* (2016) used has a very small margin of error ($R^2$=0.98, $p$<0.001).

**Statistical analyses**

The foods were divided into three main types of ethnic cuisines namely, Chinese, Malay and Indian. These foods were then ranked from the lowest to the highest energy content (per 100g). To obtain an equally represented number in each cuisine, 12 foods from each cuisine were randomly sampled using random numbers generated from Excel (Microsoft Office 2016). A one-way analysis of variance (ANOVA) was used to determine if the means of these three groups were statistically different from one another. The Welch test was used in the case of significant Levene's test. The post hoc test (Games-Howell) was obtained for the significant main effect in ANOVA. The alpha ($\alpha$) level for all statistical analyses in this study was set at 0.05. All statistical analyses were performed using Statistical Package for the Social Science (SPSS version 24).

## RESULTS

The data on the 15 foods selected from four regions, eight locations of Singapore are presented in Table 2. Despite being purchased from different locations, the energy content of the same foods was remarkably similar. The coefficient of variation (CV) for energy density was less than 10% for the following foods: *char kway teow*, fried carrot cake, chicken rice, kaya butter toast, *popiah*, *ban mian*, *mee rebus*, *ba chor mee* and economic *bee-hoon*. Foods with CV for energy content that are >10% but ≤15% included fried oyster omelette, chicken biryani, *laksa*, *roti prata*, *wanton mee* and *rojak*.

A more extensive list of measured energy density (per 100g) of the 46

**Table 2.** Summary of average measured energy (kcal/100g), portion size and total energy in each portion of 15 commonly consumed hawker foods sourced from eight regionally diverse locations within Singapore

| *Name of food* | *Location* | | | | | | | | *Mean± standard deviation* | *Coefficient of variation (CV)* |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Ang Mo Kio* | *Seng Kang* | *City Hall* | *Tiong Bahru* | *Parkway* | *Simei* | *Clementi* | *Jurong Point* | | |
| *Char kway teow* | | | | | | | | | | |
| Average energy content (kcal/100 g) | 155 | 175 | 168 | 162 | 167 | 167 | 166 | 174 | 167±6.36 | 3.82 |
| Portion size (g) | 540 | 516 | 401 | 434 | 472 | 479 | 339 | 458 | 455±63.97 | 14.06 |
| Total energy in a portion (g) | 837 | 903 | 674 | 704 | 789 | 800 | 563 | 797 | 758±106.72 | 14.07 |
| Fried carrot cake | | | | | | | | | | |
| Average energy content (kcal/100 g) | 153 | 160 | 153 | 184 | 181 | 147 | 150 | 142 | 159±15.56 | 9.80 |
| Portion size (g) | 284 | 446 | 331 | 358 | 310 | 326 | 260 | 299 | 327±56.83 | 17.38 |
| Total energy in a portion (g) | 435 | 714 | 507 | 659 | 562 | 480 | 390 | 425 | 521±115.77 | 22.20 |
| Chicken rice | | | | | | | | | | |
| Average energy content (kcal/100 g) | 443 | 430 | 558 | 437 | 502 | 584 | 541 | 425 | 164±13.04 | 7.96 |
| Portion size (g) | 316 | 253 | 365 | 262 | 306 | 322 | 307 | 265 | 300±37.72 | 12.59 |
| Total energy in a portion (g) | 443 | 430 | 558 | 437 | 502 | 584 | 541 | 425 | 490±64.46 | 13.16 |
| Fried oyster omelette | | | | | | | | | | |
| Average energy content (kcal/100 g) | 286 | 206 | 246 | 227 | 236 | 172 | † | 238 | 230±35.22 | 15.30 |
| Portion size (g) | 335 | 290 | 359 | 281 | 271 | 287 | † | 353 | 311±36.98 | 11.90 |
| Total energy in a portion (g) | 958 | 596 | 884 | 638 | 640 | 493 | † | 840 | 721±172.15 | 23.87 |
| Kaya butter toast | | | | | | | | | | |
| Average energy content (kcal/100 g) | 92 | 108 | 412 | 330 | 368 | 366 | 349 | 363 | 368±28.92 | 7.86 |
| Portion size (g) | 92 | 108 | 97 | 92 | 135 | 105 | 63 | 113 | 101±20.72 | 20.55 |
| Total energy in a portion (g) | 376 | 375 | 401 | 305 | 497 | 385 | 219 | 412 | 371±81.12 | 21.85 |

| *Name of food* | *Location* | | | | | | | | *Mean± standard deviation* | *Coefficient of variation (CV)* |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Ang Mo Kio* | *Seng Kang* | *City Hall* | *Tiong Bahru* | *Parkway* | *Simei* | *Clementi* | *Jurong Point* | | |
| *Popiah* | | | | | | | | | | |
| Average energy content (kcal/100 g) | 132 | 125 | 139 | 144 | 151 | 130 | 145 | 135 | 138±8.72 | 6.33 |
| Portion size (g) | 200 | 150 | 162 | 150 | 144 | 189 | 156 | 165 | 165±19.74 | 12.00 |
| Total energy in a portion (g) | 264 | 188 | 226 | 216 | 218 | 245 | 227 | 223 | 226±22.17 | 9.83 |
| Chicken biryani | | | | | | | | | | |
| Average energy content (kcal/100 g) | 206 | 154 | 202 | 166 | 202 | 162 | 163 | 150 | 176±23.53 | 13.40 |
| Portion size (g) | 528 | 636 | 473 | 493 | 573 | 736 | 537 | 405 | 548±102.25 | 18.67 |
| Total energy in a portion (g) | 1087 | 980 | 956 | 818 | 1157 | 1192 | 876 | 608 | 959±192.72 | 20.09 |
| Ban mian | | | | | | | | | | |
| Average energy content (kcal/100 g) | 107 | 108 | 103 | 82 | 98 | 94 | 94 | 96 | 98±8.43 | 8.62 |
| Portion size (g) | 979 | 1000 | 899 | 706 | 781 | 864 | 791 | 805 | 853±101.91 | 11.94 |
| Total energy in a portion (g) | 1048 | 1080 | 925 | 579 | 766 | 812 | 743 | 773 | 841±167.53 | 19.92 |
| *Laksa* | | | | | | | | | | |
| Average energy content (kcal/100 g) | 131 | 113 | 140 | 161 | 135 | 134 | 142 | 119 | 134±14.66 | 10.91 |
| Portion size (g) | 637 | 516 | 405 | 616 | 571 | 475 | 596 | 597 | 551±79.67 | 14.45 |
| Total energy in a portion (g) | 835 | 583 | 567 | 991 | 770 | 636 | 846 | 711 | 742±146.56 | 19.74 |
| *Mee rebus* | | | | | | | | | | |
| Average energy content (kcal/100 g) | 142 | 123 | 121 | 119 | 107 | 137 | 111 | 124 | 123±11.82 | 9.61 |
| Portion size (g) | 669 | 699 | 534 | 576 | 537 | 530 | 641 | 607 | 599±65.49 | 10.93 |
| Total energy in a portion (g) | 950 | 859 | 646 | 686 | 574 | 726 | 711 | 752 | 738±118.83 | 16.10 |

| Name of food | Location | | | | | | | | Mean± standard deviation | Coefficient of variation (CV) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ang Mo Kio | Seng Kang | City Hall | Tiong Bahru | Parkway | Simei | Clementi | Jurong Point | | |
| *Ba chor mee* | | | | | | | | | | |
| Average energy content (kcal/100 g) | 157 | 163 | 169 | 171 | 145 | 168 | 154 | 155 | 160±9.02 | 5.63 |
| Portion size (g) | 462 | 378 | 288 | 405 | 359 | 389 | 324 | 353 | 370±52.60 | 14.23 |
| Total energy in a portion (g) | 726 | 616 | 487 | 693 | 521 | 653 | 499 | 548 | 593±91.82 | 15.49 |
| *Roti prata* | | | | | | | | | | |
| Average energy content (kcal/100 g) | 374 | 347 | 349 | 299 | 282 | 338 | 344 | 391 | 341±35.76 | 10.50 |
| Portion size (g) | 243 | 221 | 132 | 138 | 349 | 215 | 142 | 242 | 210±73.30 | 34.85 |
| Total energy in a portion (g) | 909 | 766 | 462 | 411 | 985 | 728 | 488 | 947 | 712±231.46 | 32.50 |
| *Wanton mee* | | | | | | | | | | |
| Average energy content (kcal/100 g) | 126 | 134 | 160 | 169 | 175 | 157 | 115 | 175 | 151±23.31 | 15.40 |
| Portion size (g) | 358 | 438 | 424 | 303 | 270 | 304 | 379 | 288 | 345±63.95 | 18.51 |
| Total energy in a portion (g) | 450 | 587 | 679 | 512 | 472 | 478 | 436 | 504 | 515±80.81 | 15.70 |
| *Rojak* | | | | | | | | | | |
| Average energy content (kcal/100 g) | 190 | 166 | 200 | 194 | 149 | 191 | 147 | 149 | 173±22.86 | 13.20 |
| Portion size (g) | 240 | 273 | 277 | 329 | 275 | 341 | 280 | 277 | 286±32.63 | 11.39 |
| Total energy in a portion (g) | 456 | 453 | 554 | 639 | 410 | 651 | 411 | 412 | 498±101.87 | 20.45 |
| Economic *bee-hoon* | | | | | | | | | | |
| Average energy content (kcal/100 g) | 154 | 153 | 170 | 142 | 136 | 166 | 155 | 150 | 153±11.22 | 7.32 |
| Portion size (g) | 370 | 447 | 349 | 516 | 415 | 524 | 486 | 434 | 442±64.11 | 14.49 |
| Total energy in a portion (g) | 570 | 683 | 593 | 733 | 564 | 869 | 753 | 650 | 677±105.49 | 15.58 |

†Data removed due to too much oil in the fried oyster omelette (Clementi)

**Table 3.** Energy density (per 100 g), portion size and total energy in a portion of 46 additional Chinese, Malay and Indian foods

| *Ethnic group* | *Name of Food* | *Energy Content (kcal/ 100g)* | *Portion size (g)* | *Total Energy in a portion (kcal/ 100g)* |
|---|---|---|---|---|
| Chinese ($n$=16) | Prawn noodle soup | 107 | 643 | 690 |
| | *Chee cheong fun* (with sauce) | 137 | 15 | 21 |
| | *Lor mee* | 109 | 688 | 750 |
| | *Char siew wanton* noodle | 151 | 345 | 521 |
| | Fried vegetarian *bee-hoon* | 124 | 312 | 387 |
| | Steamed chicken noodle | 143 | 352 | 503 |
| | *Hokkien mee* (black sauce) | 152 | 399 | 606 |
| | Roasted duck rice | 153 | 297 | 454 |
| | Sliced fish *hor fun* | 155 | 707 | 1096 |
| | Roasted chicken rice | 164 | 330 | 541 |
| | Roasted pork rice | 170 | 311 | 529 |
| | Soya sauce chicken noodles | 174 | 258 | 449 |
| | Claypot rice | 180 | 350 | 631 |
| | *Fan choy* | 181 | 177 | 320 |
| | Rice dumpling with meat filling (Nyona style)) | 203 | 170 | 345 |
| | *Char siew pau* | 278 | 63 | 175 |
| Malay ($n$=13) | *Kentang* ball soup with rice cube | 117 | 281 | 362 |
| | *Lontong goreng* | 124 | 424 | 496 |
| | *Mee soto* | 129 | 147 | 182 |
| | *Lontong* | 142 | 269 | 382 |
| | *Nasi goreng* | 144 | 377 | 543 |
| | *Mee bakso* | 146 | 435 | 635 |
| | *Mee bundung* | 149 | 466 | 694 |
| | *Mee siam* | 151 | 329 | 497 |
| | *Gado gado* | 161 | 421 | 678 |
| | *Mee goreng* | 166 | 285 | 473 |
| | Grilled fish with rice | 183 | 310 | 567 |
| | *Nasi lemak* with chicken wing and egg | 201 | 300 | 603 |
| | *Ayam penyet* with rice (grilled) | 203 | 499 | 1013 |
| Indian ($n$=17) | *Putu mayam* | 132 | 104 | 137 |
| | *Idli* | 134 | 150 | 201 |
| | Vegetable briyani | 142 | 640 | 909 |
| | *Thosai masala* | 167 | 225 | 376 |
| | *Makhani dal* | 171 | 436 | 746 |
| | Mutton briyani (boneless) | 174 | 459 | 799 |
| | Chicken *masala* | 177 | 445 | 788 |
| | Fish *tikka* | 190 | 203 | 386 |
| | Mutton *vindaloo* | 199 | 284 | 565 |
| | *Mee goreng* | 203 | 170 | 345 |
| | *Roti John* | 230 | 418 | 961 |
| | *Thosai* | 267 | 45 | 120 |
| | Onion *prata* | 270 | 127 | 343 |
| | Egg *prata* | 292 | 130 | 380 |
| | *Chapati* | 308 | 92 | 283 |
| | *Naan* | 324 | 113 | 366 |
| | *Vadai* | 346 | 78 | 268 |

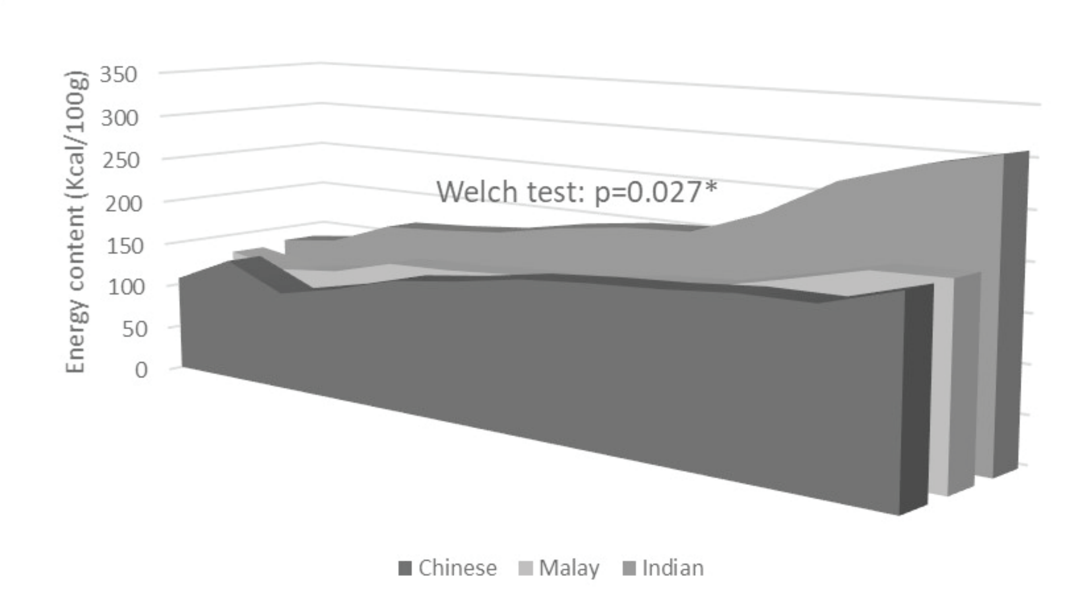


**Figure 2.** Energy content of Indian (n=12), Chinese (n=12) and Malay foods (n=12)

Chinese, Malay and Indian foods are shown in Table 3. The list of foods has been ranked from the lowest to the highest energy density. To illustrate the variability in energy density across the various ethnic food groups (Chinese, Malays, Indians), 12 foods from each group were randomly selected and plotted (Figure 2). Since 13 was the maximum number of foods in the Malay cuisine, in order to maintain consistency of number of foods selected from each ethnic group, a random selection of 12 foods per ethnic group were chosen. The figure shows a distinctively higher average energy density of Indian foods compared to Chinese and Malay foods (Welch test, $p$=0.027). Post hoc test (Games-Howell) showed that Indian foods had significantly higher energy density compared to Chinese ($p$=0.028) and Malay ($p$=0.033). Bootstrapped confidence intervals of the difference in energy density between Indians versus Chinese or Malay were 18.26-91.14 and 16.04-88.45, respectively.

## DISCUSSION

The primary objective of our study was to undertake a preliminary investigation of the variability of the energy density of commonly consumed hawker foods purchased from different locations in Singapore. The secondary objective was then to quantitate the total energy density of other commonly consumed local foods in Singapore of Chinese, Malay and Indian ethnic origin.

Our results in Table 2 indicated that for all 15 foods, the energy density (kcal or kJ/100g) was remarkably consistent for the same food regardless of the eight locations in Singapore they were purchased. This was contrary to popular belief and the frequent lament of nutritionists that the energy density of foods was so diverse within a country or a region that it was inappropriate to estimate the energy intake using FCT. Our results challenge the commonly held view that there is considerable variability in energy density of hawker foods purchased from different locations of Singapore. Since the variability in energy density is low between locations, we can assume that similar foods purchased anywhere else in Singapore have similar energy densities. A possible explanation for this may be the fact that vendors use standard ingredients, cooking methods and purchase common ingredients from a centralised supplier.

Two prominent factors that influence weight gain are the consumption of energy-dense foods and limited energy expenditure due to the lack of physical activity (Foo *et al.*, 2013). In Singapore, because of urbanization, the establishment of an obesogenic environment promotes nutritional transitions and a rapid decrease in physical activity (Malik *et al.*, 2013). Several studies have also shown a correlation between obesity and the built environment (Cummins & Macintyre, 2006; Sallis & Glanz, 2006). Various ethnic cuisines are available in local hawker centres and coffee shops, both of which are easily accessible and widely located all over Singapore (Khoo, 2017). To enable consumers to make informed choices on the foods that they consume, there is a need to provide the energy density of locally consumed foods (Table 3). Our study provides the first systematic investigation on the energy density of over 46 foods that will enable consumers to make healthier choices.

From this analysis, we found that the mean energy density (per 100 g) of Indian foods was significantly higher compared to Chinese and Malay foods ($p$=0.027). One possible explanation for the increased in energy density of Indian foods is the inclusion of foods high in oils and fats for example *briyani*, chicken *masala*, mutton *vindaloo*, *thosai*, *prata* and *vadai*. The observation that Indian foods have a higher energy density corroborates with the observation that South Asians, living especially in urban settings, have an increasing prevalence of obesity (Azmi *et al.*, 2009; Misra & Shrivastava, 2013). Despite the higher energy density of Indian foods compared to Chinese and Malay foods, there were no significant differences in total energy content of these three ethnic food groups. In contrast, in Table 2, the CV of total energy was relatively large ranging from 10.93% to 34.85%. Much of this variability in energy may be attributable to the varying portion sizes recorded in Table 2. This further reinforces the need for consumers to know both the energy density and the portion size in order to make informed choices about their energy intake.

In Singapore, there is a difference in the prevalence of obesity between the ethnic groups. Malays (20.7%) and Indians (14.0%) have the greatest prevalence of obesity compared to Chinese (5.9%) (Health Promotion Board, 2016). One possible contributor to this is the higher energy density of Malay and Indian foods. Since obesity is the outcome of being in positive energy balance, we also estimated the prevalence of physical activity in these three ethnic groups. The prevalence of leisure time physical activity was reported to be 19.2% in Chinese, 15.3% in Malays and 21.7% in Indians (unpublished). The low prevalence of physical activity and consumption of high energy-dense foods may be the contributory factors in the development of obesity in Malays. However, the higher prevalence of leisure time physical activity in Chinese and Indians compared to Malays, may suggest that in Indians, the consumption of high energy-dense foods contribute more in the etiology of obesity than the impact of inadequate leisure time physical activity. This speculation needs to be further tested and validated.

A possible strategy to reduce the prevalence of obesity and to minimise weight gain is the awareness of the energy density of various foods that people consume. We have demonstrated that the innovative instrument Calorie Answer™ is an easy to use, reproducible method to obtain rapidly the energy density of various foods (Lau *et al.*, 2016). Due to its ease of use, the Calorie Answer™ is capable of generating a large body of data on the energy density of various composite foods. It is hoped that this paper will stimulate researchers in this region to generate much needed information on the energy density of foods. Part of our objective was to validate the use of Calorie Answer™ instrument with local foods. An important limitation of this study was the modest sample that was analysed. We also wish to caution that the observations recorded in Singapore may not be reproducible in neighbouring countries such as Malaysia, Indonesia and other countries with similar ethnic demographics.

## CONCLUSION

In the absence of directly measured energy content of foods, the use of FCT may be a useful first approximation. We have provided evidence to suggest that, contrary to popular belief, the energy density of commonly consumed foods in Singapore is remarkably similar, irrespective of the region of purchase. The mean energy density (per 100 g) of Indian foods was significantly higher compared to Chinese and Malay foods ($p$=0.027). Similar work in other regions of the world will enable us to understand the variability in energy content of foods and provide public health recommendations on how best consumers can make informed choices on what they plan to eat.

**Acknowledgement**

This research was supported by the Singapore Institute for Clinical Sciences (SICS). We would like to thank Evelyn Lau, Siow Phei Ching, Winnie Chia and Penny Yeo from the Clinical Nutrition Research Centre (CNRC) for their support in our work.

**Authors' contributions**

CJH, principal investigator, conceptualized and designed the study and reviewed the manuscript; RYCQ, carried out the study, data analysis and drafting of the manuscript; GHJ, carried out the study.

**Conflict of interest**

All authors declare no conflict of interest.

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