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Energy Contents of Frequently Ordered Restaurant Meals and Comparison with Human Energy Requirements and US Department of Agriculture Database Information: A Multisite Randomized Study

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Abstract

Background—Excess energy intake from meals consumed away from home is implicated as a major contributor to obesity, and ~50% of US restaurants are individual or small-chain (non–chain) establishments that do not provide nutrition information.

Objective—To measure the energy content of frequently ordered meals in non–chain restaurants in three US locations, and compare with the energy content of meals from large-chain restaurants, energy requirements, and food database information.

Design—A multisite random-sampling protocol was used to measure the energy contents of the most frequently ordered meals from the most popular cuisines in non–chain restaurants, together with equivalent meals from large-chain restaurants.

Setting—Meals were obtained from restaurants in San Francisco, CA; Boston, MA; and Little Rock, AR, between 2011 and 2014.

Main outcome measures—Meal energy content determined by bomb calorimetry.

Statistical analysis performed—Regional and cuisine differences were assessed using a mixed model with restaurant nested within region×cuisine as the random factor. Paired *t* tests were used to evaluate differences between non–chain and chain meals, human energy requirements, and food database values.

Results—Meals from non–chain restaurants contained 1,205±465 kcal/meal, amounts that were not significantly different from equivalent meals from large-chain restaurants (+5.1%; P=0.41). There was a significant effect of cuisine on non–chain meal energy, and three of the four most popular cuisines (American, Italian, and Chinese) had the highest mean energy (1,495 kcal/meal). Ninety-two percent of meals exceeded typical energy requirements for a single eating occasion.

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STATEMENT OF POTENTIAL CONFLICT OF INTEREST
No potential conflict of interest was reported by the authors.

Supplementary materials: Tables 1, 3, and 4 are available at www.andjrnl.org

Conclusions—Non–chain restaurants lacking nutrition information serve amounts of energy that are typically far in excess of human energy requirements for single eating occasions, and are equivalent to amounts served by the large-chain restaurants that have previously been criticized for providing excess energy. Restaurants in general, rather than specific categories of restaurant, expose patrons to excessive portions that induce overeating through established biological mechanisms.

Keywords

Dietary energy; Restaurants; Obesity; Fast food; Weight gain

Rates of obesity are at epidemic levels in most countries and continue to worsen.[1] Excess energy intake is strongly implicated as an underlying contributor of obesity in the United States, based on the 217 to 491 kcal/day increase in per capita food consumption and self-reported energy intake during the past 40 years.[2,3] However, the reasons for this change are poorly understood. A detailed understanding of the specific sources of excess dietary energy is likely to lead to more nuanced approaches to obesity reduction, and the potential role of different types of restaurants requires further examination.

Meals consumed away from home have been proposed as a major contributor to rising energy intake, and previous research has noted the high energy contents of fast food and meals from large-chain restaurants,[4,5] the increasing frequency of eating out,[6] and the correlation between the frequency of fast-food consumption and high body mass index.[7–12] Fast food has been a particular focus of study because of its low cost and the availability of nutrition information. Furthermore, some,[11] but not all,[8] work has suggested that fast food may be particularly obesogenic.

In theory, eating out does not need to lead to overeating if consumers are able to practice restraint, but large portions typical of many restaurants appear to consistently override restraint and result in overeating.[13–15] Almost all research on portion size to date has focused on restaurants providing nutrition information,[13,16–18] and to our knowledge only one study has measured the energy content of foods prepared by restaurants that do not provide nutrition information.[19] Moreover, that study was conducted in a single city, and the extent to which excess energy in restaurant food is a ubiquitous problem or a problem specific to particular classes of restaurants is uncertain. Such information is needed for the design of more targeted and, hopefully, more effective, public health interventions.

Therefore, previous work[19] was extended to conduct a multisite investigation of the energy contents of the most frequently ordered meals from the most popular types of individual and small-chain (non–chain) restaurants in different regions of the United States. Results were compared with both normative data on human energy requirements and data for equivalent meals from large-chain restaurants.

MATERIALS AND METHODS

The energy contents of a representative sample of meals were measured from randomly selected non–chain restaurants in three geographically diverse cities (Little Rock, AR;

Boston, MA; and San Francisco, CA) together with data for matching meals from large-chain restaurant meals. Four hundred twenty meals were collected between 2011 and 2014, which to our knowledge makes this the largest study of its kind. A subset of the Boston data was published previously.[19] This study was deemed exempt under federal regulation 45 CFR §46.101(b).

Selection of Restaurants and Food

Five non–chain establishments (ie, independent restaurants and small chains with fewer than 20 outlets) in each of the nine most popular cuisines[20] in three geographical regions were targeted for random selection from a comprehensive list of restaurants generated by Internet searches of regional restaurants. Restaurants had to be within 25 miles of downtown Boston or Little Rock, or 10 miles of downtown San Francisco, to ensure a robust pool of restaurants within each region. Random selection was achieved by assigning a number to eligible restaurants, generating a random order of numbers, and selecting the first five for each category in each region. Restaurants that did not have all eligible meals were excluded, and the next restaurant on the list was selected. Due to a shortage of eligible restaurants in some regions, 364 meals from 123 non–chain restaurants were collected.

Large-chain restaurants in the top 400 for sales[21] were also targeted that had ≥1 outlet in ≥2 regions and offered the same entrées targeted in the non–chain restaurants. Matching meals were collected from the same chains in all regions where possible, and there were 56 equivalent meals from 21 large chains (9, 5, and 7 restaurants in Boston, San Francisco, and Little Rock, respectively).

Within cuisines, targeted meals were the three most frequently ordered entrées and accompanying side dishes, as described previously (entrées and side dishes are the most frequently ordered items[19,22]). The same entrées were ordered by researchers from each targeted restaurant to examine variability between restaurants and regions. Dinner-sized portions of the target meals were ordered as takeout by researchers, who did not identify themselves as such. Restaurants were asked to separately package individual food items.

Energy Determination

Purchased meals were transported to the local team's laboratory and weighed. Meals collected in San Francisco and Little Rock were packaged in freezer-safe bags and shipped on dry ice to Boston. The energy contents of meal components were determined using a validated bomb calorimetry method accurate to 2%.[19,23] In brief, foods were blended, freeze-dried, and ground into a homogenous powder, and the heat of combustion was quantified in duplicate samples using benzoic acid as a standard. The total (gross) energy of each food was determined as the product of total dried food weight and the mean heat of combustion of the duplicates.

Statistical Analysis

Meal gross energy content was the primary outcome, and portion size (in grams) and energy density (kilocalories per gram) were also examined. Descriptive statistics of both individual meals (entrées plus sides) and entrées by themselves were obtained, and meal values were compared with normative values for human energy requirements.[24] Regional and cuisine differences were assessed using a mixed model with restaurant nested within region times cuisine type as the random factor, and American cuisine and the Boston region were used as references. Separate mixed models were fit to examine the effects of portion size, energy density, and gross energy on each other across all regions, cuisines, and meals. The same random factor above was the only covariate in these models. Mean paired differences of non–chain and chain meals were compared with zero using a paired *t* test and were compared by cuisine type using analysis of variance with least square means and the Tukey post hoc test.

Restaurant foods in the current Nutrient Database for Standard Reference at the time of the study (SR-27) (US Department of Agriculture [USDA]) with independently measured nutrient information for items that matched study foods were identified and extracted for comparison with equivalent meals from non–chain restaurants using a paired *t* test. Standard Atwater factors were used to revert the SR-27 energy values to gross energy values using the equation: gross energy=(fat g×9.4)+(protein g×5.65)+(total carbohydrates g×4.15) as previously described.[19,23] Thus, measured energy from foods in this study could be directly compared to equivalent energy values in SR-27. Before analyses (conducted by LEU) (SAS for Windows, version 9.3, 2011, SAS Institute Inc), data with nonnormal distribution were transformed. Values are presented as means±standard deviation unless noted.

RESULTS

Meals from non–chain restaurants contained 1,205±465 kcal energy, which is ~55% of the typical daily energy requirement of 2,000 kcal/day for an adult woman and ~44% of the typical daily energy requirement of 2,500 kcal/day for an adult man after accounting for typical energy losses in digestion.[24] Variability in meal energy content was very high (±465 kcal; range=113 to 3,008 kcal/meal) (Table 1, available online at www.andjrnl.org), and 92% contained more than 570 kcal, which can be used as a benchmark for the energy requirement of a typical adult woman at a single lunch or dinner meal, as justified below. Mean portion weight of meals was 689±261 g, and mean meal energy density was 1.87±0.68 kcal/g. The entrées provided most of the meal energy content (1,000±430 kcal, data not shown), and sides came with 49% of meals (398±26 kcal). The energy contents, portion sizes, and energy density of specific cuisines within regions are given in Table 2.

Figure 1 summarizes meal energy content, portion size, and energy density by cuisine and region, and Tables 3 and 4 (available online at www.andjrnl.org) show the statistical model predicting meal energy content, portion size, and energy density from region, cuisine, and restaurant, using American cuisine and Boston as the references for comparison. There was substantial difference in mean meal energy content among cuisines. Specifically, Italian, Chinese, and Indian meals were not significantly different in energy content from American meals (1,556±492, 1,478±525, and 1,250±324 kcal/meal vs 1,451±400 kcal/meal, respectively), but Greek, Japanese, Vietnamese, Mexican, and Thai contained less energy, by 20% to 38%, and Greek meals had the lowest mean value (904±413 kcal). Overall the three cuisines with the highest mean energy (American, Italian, and Chinese) averaged 1,485 kcal/meal. In addition, there were some regional differences in meal energy content of modest magnitude. Specifically, compared with meals from Boston, meals from Little Rock and San Francisco contained significantly less energy (1,268 vs 1,179 and 1,166 kcal/meal, respectively; P=0.03 for both) and had smaller portions (737 vs 644 and 679 g/meal, respectively; $P \leq 0.03$); however, after adjusting the alpha to .003 for multiple comparisons, none of the differences remained significant, and 64% of between-meal variability in energy content was not accounted for by cuisine and region. There were no significant differences among regions in meal energy density ($P \geq 0.69$).

To further evaluate predictors of meal energy content, relationships between meal portion weight, meal energy density, and meal energy content were explored across all cuisines, regions, and meal types. As shown in Figure 2, both portion weight and meal energy density significantly predicted meal energy content, and portion size was also inversely correlated with energy density. Individually, both portion size and energy density were only weakly predictive of meal energy content (partial $R^2 \leq 0.25$).

In addition to the analysis comparing data within non–chain restaurants, the non–chain data were evaluated against comparable data for meals from large-chain restaurants. For this analysis, 56 meals from large-chain restaurants were identified that matched 171 meals from non–chain restaurants, and a comparison was made both for total meals and for entrées alone. The matching large-chain meals contained 68 fewer kilocalories than non–chain meals (P=0.41) (Table 5). Comparisons of large-chain and non–chain meals by cuisine type were also not significant ($P \geq 0.10$). In addition, no site differences were found for the large-chain meals (data not shown, P=0.73).

The data for non–chain meals were further compared with equivalent data from the current national USDA database. The database contained independently measured energy values for only nine items that matched foods in our study, although the study measured the most frequently ordered items (Table 6). On average, the database values were 15 kcal/food (2.3%) less than measured values (P=0.44). It should be noted that the SR-27 database used here is an updated USDA database; our previous study indicating underestimation of restaurant meal energy contents was performed with release 24, which had only four food matches for comparison.

DISCUSSION

Meals consumed away from home are recognized to be an important contributor to the increase in energy intake since 1970.[25] Recent legislation requiring restaurants with ≥20 outlets to disclose nutrition information[26] may help increase selection of menu items with lower energy, but only ~50% of restaurant outlets will be affected by the new legislation. To our knowledge, only one previous study has measured the energy content of meals from restaurants that do not disclose nutrition information,[19] and that study was conducted in a single city. This multisite study provides the most comprehensive information to date on the energy contents of the most frequently ordered meals from the most popular non–chain restaurant categories in the United States. Ninety-two percent of all measured meals contained amounts of energy that were in excess of human energy needs at a single meal, and amounts were comparable to those provided by the fast-food and large-chain restaurants that have previously been criticized for their role in the obesity epidemic.[27] These new results suggest that restaurants in general, rather than specific types of restaurant, may facilitate high energy intake and obesity via excessive portion sizes. Based on this observation, new public health approaches to obesity reduction that include restaurants in general may be appropriate.

The primary finding of this study conducted in three geographically dispersed cities with very different socioeconomic profiles was that a wide range of non–chain restaurants lacking nutrition information served meals averaging 1,205 kcal/meal of gross energy for just a single entrée plate without appetizers, desserts, or energy-containing beverages, and that there is very large variability in energy between individual meals (range=113 to 3,008 kcal/meal). Moreover, three of the four most popular cuisines (American, Italian, and Chinese) contained even more energy, averaging 1,495 kcal/meal. There was a significant effect of cuisine on meal energy content, but variability between meals was substantial and the relationships between meal energy content and portion size and energy density were weak, making it likely impossible for consumers to use visual cues such as portion size to accurately estimate the energy content of provided meals. These results confirm and extend our previous observation of extremely high energy values and high meal variability in one city,[19] and in addition now demonstrate comparably high energy values to those served in large-chain restaurants providing nutrition information.

Interpreting portion sizes requires an understanding of both human energy requirements and cultural norms for meal frequency. Studies using gold-standard methodology show that adult women living in the United States require ~2,000 kcal/day to maintain weight (range=1,500 to 2,500 kcal/day depending on age, height, and activity), whereas men require ~2,500 kcal/day (range=2,000 to 3,000 kcal/day). It should be noted that these values are not low by the standards of human beings who are far more physically active; for example, modern-day subsistence farmers and hunter-gatherers,[28,29] because energy expenditure for non–activity energy needs such as basal metabolism is the major determinant of energy requirements. Concerning eating patterns, national surveys indicate that three meals and one or more snacks per day is typical in the United States,[30] with 57% of daily energy consumed at lunch plus dinner.[31] For an adult woman requiring 2,000 kcal/day, the average energy content of a restaurant meal measured in this study provides the equivalent of two full meals. For an older, shorter woman requiring only 1,500 kcal/day, the same meal would provide 2.6 full meals, whereas for a tall young man it would be 1.3 full meals. These theoretical calculations underestimate the contribution of restaurants to excess energy, because, as noted above, three of the four most popular cuisines (American, Italian, and Chinese) also provide substantially more energy than average, and the meals tested in this study did not include drinks or additional courses. Nevertheless, they do illustrate that amounts of energy in typical restaurant meals can cause weight gain in large segments of the population unless there is compensation at other times of the day, which several studies indicate does not occur,[14] and are consistent with data for restaurants providing nutrition information.[32] It is also important to note that, in addition to their direct effect on energy intake, large restaurant portions may set up normative expectations regarding excessive portion size that may further increase energy intake at home.[17]

Sixty-three percent of obese adults try to lose weight each year,[33] and self-monitoring food intake is nationally recommended.[34] Therefore, one interpretation of the results obtained here is the suggestion that the new mandatory disclosure of calorie information[35] should be extended to non–chain restaurants. It is anticipated that this measure will be insufficient as a sole strategy to reduce obesity because, to date, the measured effects of calorie labeling on food choice and consumption have been nonexistent or small,[35–38] which may be due to consumers' limited ability to predict their own needs.[39] This is not surprising when viewed from the biological perspective that exposure to large portions causes greater activation of the neurologic reward system and the autonomic nervous system than small portions (because the food exposure period is extended), which in turn results in persistent desire for food while food exposure exists and increased desire to eat.[40,41] These biological mechanisms explain why large portions are consumed in amounts proportional to portion size.[6,14,42] Mandatory menu labeling in all restaurants would help provide information, but based on these observations would not address the basic problem that human neurobiology, rather than lack of willpower, is a primary driver of overeating restaurant meals when excessive portions are served.

Because large portions encourage overeating, and restaurants provide large portions, there has been much interest in policies that might help nudge consumers to reduced-calorie choices in restaurants. Previous proposals to address this issue have included taxation of calories,[43] mandatory restriction of portion sizes,[44] and restriction of locations where fast food can be sold.[45] Such policies are not mutually exclusive, but are likely to face substantial barriers in acceptance and implementation both from consumers and restaurant owners. Based on our finding that restaurants in general, rather than specific types of restaurants, serve excessively large portions, an alternative policy that could also be tested for effectiveness would be to give consumers the right to request half or one-third portions at proportional pricing. Such a policy, which does not exist today, would not restrict what restaurants offer or what consumers eat, but could allow additional choice by permitting people to choose portion size at the time of ordering, before the presentation of large portions triggers overeating. Because the same rules could be applied to all restaurants in a given area, this approach could nudge competitors toward innovation and business practices that improve quality and pricing in every dimension except large portions. Somewhat similar laws currently do this for some unit pricing requirements.[45–50] For example, municipal ordinances and state laws that establish a consumers' right to order smaller portions at proportionally lower prices would give restaurant consumers the same control they enjoy over food consumed at home, and eliminate restaurants' incentives to offer the excessively large portions observed in this study. Future research should also explore what additional behavior-based nudges might be required for success if this new approach is adopted.

Limitations

Although to our knowledge this is the largest study of its kind, it was not possible to study all types of foods purchased in restaurants or all times of day. To be able to compare data across sites with sufficient power, collections were restricted to dinner-size portions of entrées and the sides that came with them, ordered as a takeout, and did not order breakfast items, café items, appetizers, desserts, or drinks. Pizza was also excluded because of the uncertainty over portion size. For these reasons, although the results indicate that restaurants substantially over-provide dietary energy to customers, they undoubtedly underestimate the full extent to which this occurs. Another study limitation is that only the energy content and energy density of foods were measured. Future studies will ideally add macronutrient contents and dietary fiber as well.

CONCLUSIONS

This multisite study found that non–chain restaurants provide amounts of dietary energy that are far in excess of human energy requirements, and are similar to amounts provided by the fast-food and large-chain restaurants that have previously been associated with promoting obesity. This study extends previous work and indicates that restaurants in general, rather than specific types of restaurants, can facilitate obesity by exposing patrons to portion sizes that induce overeating through established biological mechanisms that are largely outside conscious control. Based on these observations, new regulatory approaches to preventing involuntary overeating of restaurant meals may be appropriate, which may reduce the current incentive for restaurants to provide excessive portions.

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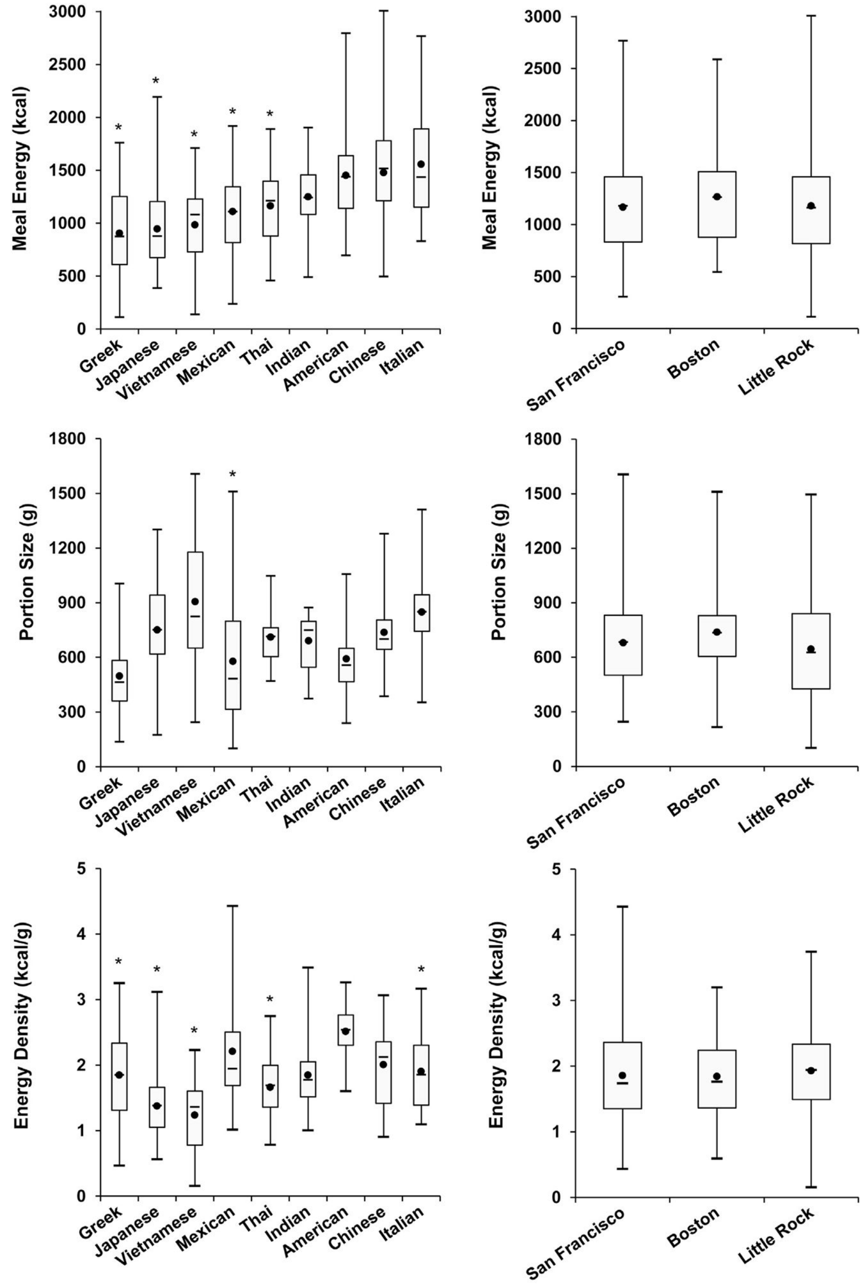

Figure 1.

Boxplot of gross meal energy, portion size, and meal energy density by cuisine and by region in non–chain restaurants. Cuisines are in order of lowest to highest mean meal energy, and regions are ordered by lowest to highest prevalence of overweight and obesity by state: San Francisco, CA=55.1%, Boston, MA=56.8%, and Little Rock, AR=70.6%. Circles indicate means, lines within the boxes indicate medians. *Differences ($P \leq 0.00017$) from American meals (reference values) obtained from a mixed model accounting for the clustered nature of data around restaurant, cuisine, meal, and region (restaurant nested within region×cuisine type was the random factor). The alpha was adjusted to .00017 for multiple comparisons.

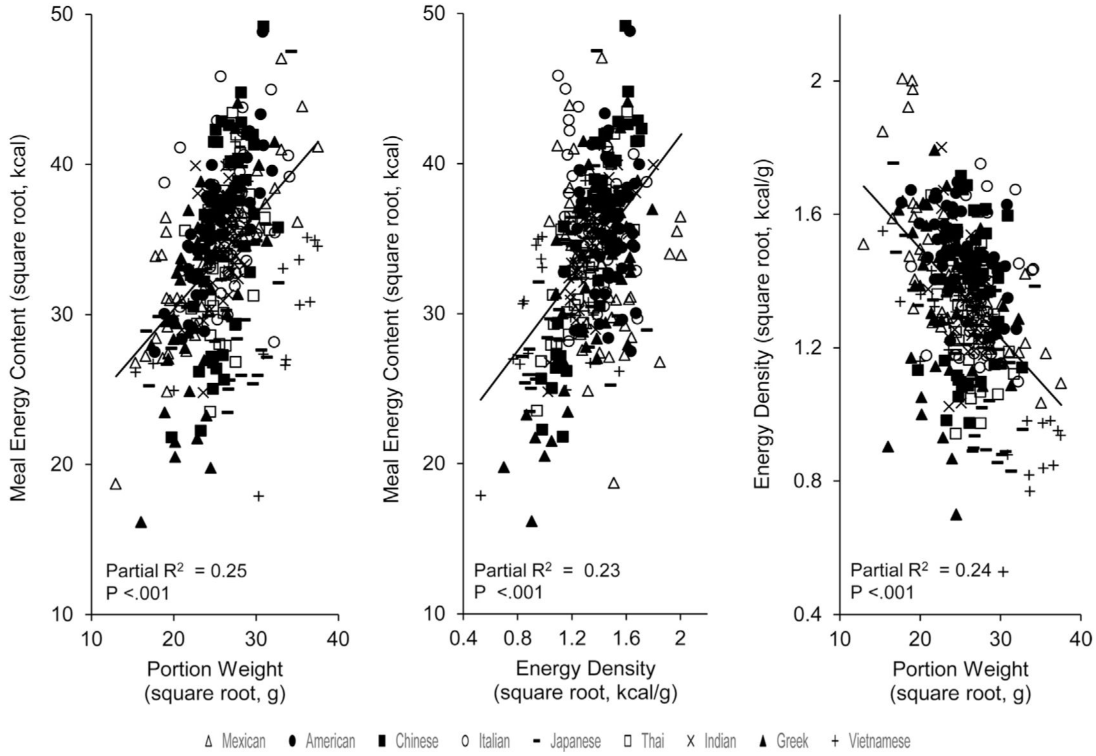

Figure 2.

Relationships between meal portion weight, meal energy density, and meal energy content. Partial R^2 values were calculated from a mixed model with restaurant nested within region×cuisine type as the random factor and only covariate.

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Table 1

Mean±standard deviation (SD) meal energy, portion size, and energy density of non–chain individual restaurant meals from Boston, MA; San Francisco, CA; and Little Rock, AR

Meal	n	Gross energy (kcal)	Portion (g)	Energy density (kcal/g)
		←——— *mean±SD* ———	———	——→
Mexican				
Chicken fajitas				
Boston	5	1,324±373	1,013±420	1.39±0.29
San Francisco	5	1,411±169	818±112	1.73±0.19
Little Rock	5	1,569±344	866±185	1.84±0.35
All sites	15	1,434±304	899±266	1.65±0.33
Cheese quesadilla				
Boston	5	1,059±271	575±245	2.01±0.52
San Francisco	5	1,158±205	293±17	3.97±0.72
Little Rock	5	859±332	328±126	2.73±0.72
All sites	15	1,025±285	399±197	2.90±1.04
Beef tacos				
Boston	5	968±266	487±192	2.06±0.31
San Francisco	5	870±248	447±154	1.99±0.40
Little Rock	5	778±356	375±187	2.15±0.30
All sites	15	872±284	436±172	2.07±0.32
American				
Cheeseburger				
Boston	5	1,344±496	497±160	2.71±0.35
San Francisco	5	1,458±198	559±93	2.62±0.18
Little Rock	5	1,434±180	571±66	2.52±0.31
All sites	15	1,412±305	543±110	2.62±0.28
Ribeye steak				
Boston	5	1,605±394	735±246	2.29±0.50
San Francisco	5	1,729±250	783±159	2.30±0.62
Little Rock	5	1,844±604	730±222	2.57±0.51
All sites	15	1,726±420	749±198	2.38±0.52
Grilled chicken sandwich				
Boston	5	1,336±470	540±91	2.43±0.57
San Francisco	5	1,172±200	455±69	2.59±0.32
Little Rock	5	1,140±170	449±82	2.58±0.37
All sites	15	1,216±301	481±87	2.53±0.41
Chinese				
Beef and broccoli				
Boston	5	846±107	681±68	1.24±0.05
San Francisco	5	617±108	531±105	1.18±0.21
Little Rock	5	1,447±316	937±287	1.61±0.33

Meal	n	Gross energy (kcal)	Portion (g)	Energy density (kcal/g)
All sites	15	970±408	717±241	1.34±0.29
Pork fried rice				
Boston	5	1,708±164	785±96	2.18±0.11
San Francisco	5	1,453±208	651±92	2.24±0.24
Little Rock	5	1,551±115	758±104	2.06±0.17
All sites	15	1,571±189	732±109	2.16±0.18
General Tso’s chicken				
Boston	5	1,892±236	669±59	2.83±0.27
San Francisco	5	1,614±263	693±128	2.36±0.35
Little Rock	5	2,176±595	924±182	2.35±0.37
All sites	15	1,894±440	762±171	2.51±0.38
Italian				
Lasagna				
Boston	4	1,547±245	898±172	1.73±0.10
San Francisco	5	1,315±491	742±218	1.80±0.48
Little Rock	3	1,436±588	674±252	2.13±0.21
All sites	12	1,422±422	777±214	1.86±0.35
Spaghetti and meatballs				
Boston	4	1,566±268	1102±272	1.44±0.13
San Francisco	5	1,445±510	975±294	1.51±0.48
Little Rock	3	1,470±625	858±93	1.68±0.54
All sites	12	1,492±434	988±250	1.53±0.39
Fettuccini alfredo				
Boston	4	2,221±262	866±138	2.61±0.43
San Francisco	5	1,562±710	768±245	2.18±0.93
Little Rock	3	1,451±289	679±141	2.15±0.23
All sites	12	1,754±582	778±190	2.31±0.65
Japanese				
Chicken teriyaki				
Boston	4	1,168±121	959±218	1.25±0.21
San Francisco	5	939±151	740±120	1.27±0.12
Little Rock	5	1,040±669	684±410	1.58±0.32
All sites	14	1,041±396	782±285	1.38±0.26
Beef yaki udon				
Boston	5	764±68	809±213	1.00±0.25
San Francisco	5	531±47	869±122	0.61±0.04
Little Rock	5	824±276	836±178	1.05±0.49
All sites	15	706±202	838±164	0.89±0.36
Vegetable tempura				
Boston	5	1,293±395	675±320	2.14±0.62
San Francisco	5	1,076±282	714±274	1.61±0.37
Little Rock	5	912±462	510±240	1.84±0.42

Meal	n	Gross energy (kcal)	Portion (g)	Energy density (kcal/g)
All sites	15	1,094±393	633±275	1.86±0.50
Thai				
Chicken pad Thai				
Boston	5	1,486±254	647±126	2.33±0.31
San Francisco	5	1,529±216	762±54	2.00±0.17
Little Rock	1	1,172	560	2.09
All sites	11	1,477±235	691±113	2.16±0.28
Chicken drunken noodles				
Boston	5	1,063±266	683±122	1.55±0.16
San Francisco	5	1,077±237	639±90	1.67±0.18
Little Rock	1	894	493	1.81
All sites	11	1,054±232	646±111	1.63±0.18
Vegetable red curry				
Boston	5	840±133	746±130	1.13±0.11
San Francisco	5	1,019±425	796±165	1.25±0.39
Little Rock	1	1,233	1,006	1.23
All sites	11	957±309	793±153	1.19±0.27
Indian				
Chicken tikka masala				
Boston	5	1,427±147	752±45	1.90±0.16
San Francisco	5	1,399±301	548±167	2.66±0.63
Little Rock	3	1,206±314	701±68	1.72±0.36
All sites	13	1,365±250	662±141	2.15±0.59
Palak paneer				
Boston	5	1,431±140	783±62	1.83±0.17
San Francisco	5	1,246±540	598±194	2.07±0.52
Little Rock	3	1,192±362	646±199	1.85±0.10
All sites	13	1,305±370	680±167	1.93±0.34
Lamb vindaloo				
Boston	5	1,150±81	787±61	1.46±0.09
San Francisco	5	954±463	634±182	1.46±0.41
Little Rock	3	1,170±48	793±5	1.47±0.05
All sites	13	1,079±291	729±136	1.46±0.24
Greek				
Greek salad				
Boston	5	938±232	533±107	1.77±0.34
San Francisco	5	458±159	403±104	1.13±0.22
Little Rock	5	348±242	395±174	0.86±0.29
All sites	15	581±331	444±139	1.26±0.48
Lamb or beef kebab				
Boston	5	1,345±220	847±103	1.60±0.25
San Francisco	5	1,185±399	619±178	1.92±0.39

Meal	n	Gross energy (kcal)	Portion (g)	Energy density (kcal/g)
Little Rock	5	754±353	390±207	1.98±0.21
All sites	15	1,095±402	619±248	1.83±0.32
Lamb or beef gyro				
Boston	5	958±224	386±89	2.49±0.25
San Francisco	5	1,164±464	522±135	2.16±0.40
Little Rock	5	986±201	374±115	2.70±0.38
All sites	15	1,036±310	427±127	2.45±0.40
Vietnamese				
Beef pho				
Boston	4	950±176	1,365±142	0.70±0.11
San Francisco	5	861±351	1,341±252	0.62±0.15
Little Rock	2	645±716	1,196±424	0.46±0.43
All sites	11	854±350	1,324±231	0.62±0.20
Pork vermicilli				
Boston	4	868±312	559±232	1.65±0.42
San Francisco	5	1,168±354	746±152	1.55±0.21
Little Rock	2	494±98	399±150	1.28±0.24
All sites	11	936±385	615±216	1.54±0.31
Lemongrass chicken				
Boston	3	1,271±51	830±160	1.56±0.25
San Francisco	5	1,063±268	674±191	1.60±0.27
Little Rock	2	1,326±132	879±160	1.52±0.13
All sites	10	1,178±223	762±183	1.57±0.22

Table 2

Mean±standard deviation (SD) gross energy, portion size, and energy density from non–chain restaurant meals in San Francisco, CA; Boston, MA; and Little Rock, AR

Cuisine type[a]	n	Gross energy (kcal)	Portion size (g)	Energy density (kcal/g)
		←———	*mean±SD*	———→
Mexican				
San Francisco	15	1,146±300	519±250	2.57±1.13
Boston	15	1,117±325	692±367	1.82±0.48
Little Rock	15	1,068±487	523±296	2.24±0.60
All cities	45	1,110±372	578±312	2.21±0.83
American				
San Francisco	15	1,453±310	599±177	2.50±0.41
Boston	15	1,429±441	591±196	2.47±0.48
Little Rock	15	1,472±459	583±177	2.56±0.38
All cities	45	1,451±400	591±180	2.51±0.42
Chinese				
San Francisco	15	1,228±490	625±124	1.93±0.60
Boston	15	1,482±500	712±89	2.08±0.69
Little Rock	15	1,725±495	873±208	2.01±0.42
All cities	45	1,478±525	737±179	2.01±0.57
Italian				
San Francisco	15	1,440±546	828±259	1.83±0.68
Boston	12	1,778±402	955±213	1.93±0.57
Little Rock	9	1,452±453	737±177	1.98±0.39
All cities	36	1,556±492	848±236	1.90±0.57
Japanese				
San Francisco	15	849±296	774±186	1.17±0.48
Boston	14	1,069±333	804±265	1.48±0.65
Little Rock	15	925±468	676±304	1.49±0.51
All cities	44	945±376	750±256	1.37±0.56
Thai				
San Francisco	15	1,208±370	732±126	1.64±0.41
Boston	15	1,130±347	692±124	1.67±0.55
Little Rock	3	1,100±181	686±279	1.71±0.44
All cities	33	1,163±341	710±138	1.66±0.47
Indian				
San Francisco	15	1,200±455	593±172	2.06±0.71
Boston	15	1,336±179	774±55	1.73±0.24
Little Rock	9	1,189±241	713±123	1.68±0.25
All cities	39	1,250±324	690±148	1.85±0.50
Greek				
San Francisco	15	935±486	515±160	1.74±0.55

Cuisine type[a]	n	Gross energy (kcal)	Portion size (g)	Energy density (kcal/g)
Boston	15	1,080±285	589±220	1.96±0.48
Little Rock	15	696±372	386±157	1.85±0.83
All cities	45	904±413	497±196	1.85±0.63
Vietnamese				
San Francisco	15	1,031±330	921±362	1.26±0.51
Boston	11	1,008±262	926±401	1.28±0.53
Little Rock	6	822±515	825±417	1.09±0.55
All cities	32	984±347	904±375	1.23±0.51
All meals				
San Francisco	135	1,166±441	679±247	1.85±0.77
Boston	127	1,268±414	737±256	1.84±0.61
Little Rock	102	1,179±545	644±276	1.93±0.64
All cities	364	1,205±465	689±261	1.87±0.68

[a]Cuisines are presented in order of most prevalent to least prevalent.

Table 3

Predictors of gross energy, portion size, and energy density of meals from non–chain restaurant meals in San Francisco, CA; Boston, MA; and Little Rock, AR, in a mixed model[a]

	Gross Energy (Square Root)[b]		Portion Size (Square Root)[b]		Energy Density (Not Transformed)[b]	
Model	**β[c]±standard error**	***P* value[d]**	**β[c]±standard error**	***P* value[d]**	**β[c]±standard error**	***P* value[d]**
Fixed effects						
Intercept	42.45±1.40	<0.0001	28.01±1.01	<0.0001	2.36±.11	<0.0001
Region						
Boston	0		0		0	
Little Rock	−1.83±.85	0.03	−1.65±.61	<0.01	.03±.06	0.58
San Francisco	−1.68±.78	0.03	−1.27±.56	0.03	.03±.06	0.59
Cuisine						
American	0		0		0	
Chinese	−1.71±1.86	0.36	−.15±1.35	0.91	−.22±.15	0.15
Greek	−8.76±1.86	<0.0001	−2.79±1.35	0.04	−.55±.15	<0.0001
Indian	−5.62±1.93	0.004	−1.35±1.40	0.34	−.46±.16	<0.01
Italian	−3.05±1.98	0.13	4.05±1.43	<0.01	−.86±.16	<0.0001
Japanese	−8.77±1.86	<0.0001	−2.62±1.35	0.05	−.52±.15	<0.0001
Mexican	−9.56±1.86	<0.0001	−7.65±1.35	<0.0001	.52±.15	<0.01
Thai	−10.96±2.03	<0.0001	0.66±1.47	0.65	−1.19±.17	<0.0001
Vietnamese	−11.33±2.03	<0.0001	−2.83±1.47	0.06	−.85±.17	<0.0001
Meal (cuisine)[e]						
Restaurant (region×cuisine)	6.82±1.88	<0.0001	3.57±.98	<0.0001	.02±.01	0.06
Residual	19.20±1.81	<0.0001	10.05±.95	<0.0001	.16±.02	<0.0001

[a] Values are from mixed multivariate models with either gross energy, portion size, or energy density as the dependent variable.

[b] Gross energy and portion size values were transformed (square root) to achieve a normal distribution. Energy density values were normally distributed without transformation.

[c] Beta values describe the change in the dependent variable (square root of gross energy, square root of portion size, or energy density) for every 1 unit of change in the fixed effects holding all other effects equal.

[d] The alpha is adjusted to <.00017 for multiple comparisons.

[e] See Table 4 for beta estimates of specific meals.

Table 4

Meal effect from Table 3, which provides predictors of gross energy, portion size, and energy density from non–chain restaurant meals in San Francisco, CA; Boston, MA; and Little Rock, AR, in a mixed model[a]

	Gross Energy (Square Root)		Portion Size (Square Root)		Energy Density (Square Root)	
Fixed effect: Meal (cuisine)	**β^b±standard error**	***P* value[c]**	**β^b±standard error**	***P* value[c]**	**β^b±standard error**	***P* value[c]**
Mexican						
Chicken fajitas	0		0		0	
Cheese quesadilla	−5.94±1.60	<0.0001	−10.22±1.16	<0.0001	.40±.05	<0.0001
Beef tacos	−8.58±1.60	<0.0001	−9.23±1.16	<0.0001	.16±.05	0.003
American						
Ribeye steak	0		0		0	
Cheeseburger	−3.93±1.60	0.01	−3.97±1.16	<0.0001	.08±.05	0.13
Grilled chicken sandwich	−6.64±1.60	<0.0001	−5.28±1.16	<0.0001	.05±.05	0.33
Chinese						
General Tso’s chicken	0		0		0	
Pork fried rice	−3.70±1.60	0.02	−.47±1.16	0.68	−.11±.05	0.03
Beef and broccoli	−12.71±1.60	<0.0001	−1.01±1.16	0.38	−.43±.05	<0.0001
Italian						
Fettuccini alfredo	0		0		0	
Lasagna	−4.04±1.79	0.02	−.07±1.29	0.96	−.15±.06	0.01
Spaghetti and meatballs	−3.11±1.79	0.08	3.54±1.29	0.007	−.28±.06	<0.0001
Japanese						
Vegetable tempura	0		0		0	
Chicken teriyaki	−0.57±1.63	0.73	3.02±1.18	0.01	−.18±.05	0.0006
Beef yaki udon	6.17±1.60	<0.0001	4.31±1.16	<0.0001	−.43±.05	<0.0001
Thai						
Chicken pad Thai	0		0		0	
Chicken drunken noodles	−6.03±1.87	0.001	−.87±1.35	0.52	−.19±.06	0.002
Vegetable red curry	−7.77±1.87	<0.0001	1.84±1.35	0.18	−.38±.06	<0.0001
Indian						
Chicken tikka masala	0		0		0	

Fixed effect: Meal (cuisine)	Gross Energy (Square Root)		Portion Size (Square Root)		Energy Density (Square Root)	
	β^b±standard error	*P* value[c]	β^b±standard error	*P* value[c]	β^b±standard error	*P* value[c]
Palak paneer	−1.05±1.72	0.54	0.31±1.24	0.81	−.07±.06	0.21
Lamb vindaloo	−4.29±1.72	0.01	1.31±1.24	0.29	−.25±.06	<0.0001
Greek						
Lamb or beef kebab	0		0		0	
Lamb or beef gyro	0.66±1.60	0.40	−3.87±1.16	0.001	.21±.05	<0.0001
Greek salad	−9.38±1.60	<0.0001	−3.56±1.16	0.002	−.25±.05	<0.0001
Vietnamese						
Pork vermicilli	0		0		0	
Chicken lemongrass	4.21±1.92	0.03	3.06±1.39	0.03	.02±.06	0.79
Beef pho	−1.57±1.87	0.40	11.86±1.35	<0.0001	−.46±.06	<0.0001

[a]See Table 3 for the full model, which also includes region and cuisine as fixed effects and restaurant (region×cuisine) as a random effect.

[b]Beta values describe the change in the dependent variable (square root of gross energy, square root of portion size, or energy density) for every 1 unit of change in the fixed effects holding all other effects equal.

[c]The alpha for meals is adjusted to <.00017 for multiple comparisons.

Table 5

Gross energy of non–chain meals and entrées compared with matching chain meals and entrées

	Gross Energy of Meals (kcal)				
	Non–chain		Chain		
Cuisine type	**n**	**Mean–SD**[a]	**n**	**Mean–SD**	***P* value**
Mexican	45	1,110±372	14	1,207±220	0.53
American	45	1,451±400	19	1,327±442	0.56
Chinese	45	1,478±525	5	1,277±189	0.52
Italian	36	1,556±492	18	1,423±203	0.10
All cuisines	171	1,391±478	56	1,323±313	0.41

	Gross Energy of Entrées (kcal)				
	Non–chain		Chain		
	n	**Mean–SD**	**n**	**Mean–SD**	***P* value**
Mexican	44	817±319	14	947±213	0.16
American	40	855±229	19	851±283	0.94
Chinese	45	1,401±536	5	1,212±174	0.54
Italian	36	1,183±425	18	987±221	0.08
All cuisines	165[b]	1,065±465	56	951±254	0.48

[a]SD=standard deviation.

[b]Non–chain entrée sample size is different from meal sample size because six meals were processed together and entrées were not separated from sides.

TABLE 6

Serving size and measured energy content of restaurant entrées with data available for serving and energy in the US Department of Agriculture Nutrient Database for Standard Reference version 27 (SR-27)

	SR-27			Bomb Calorimetry		
Restaurant food item	Serving (g)	Metabolizable energy (kcal)	Gross energy[a] (kcal)	Serving (g)	Gross energy (kcal)	Gross energy difference calorimetry SR-27 (kcal)
Cheese quesadilla	205	754	834	353	861	27
Beef tacos	281	615	694	306	623	−71
Beef and broccoli	574	603	689	677	890	200
General Tso's chicken	535	1,578	1,745	725	1,820	74
Lasagna	457	845	954	580	1,013	58
French fries	170	491	520	197	508	−12
Spanish rice	116	215	229	140	207	−22
Refried beans	148	231	255	146	211	−44
Egg rolls	89	223	242	70	170	−72
All foods[b]	286±187	617±429	684±479	355±247	700±527	15[c]±87

[a]Gross energy for SR-27 calculated using macronutrient values and their heats of combustion according to the equation gross energy=9.4 kcal×fat (in grams)+4.15 kcal total carbohydrate (in grams) +5.65×protein (in grams).

[b]Values are presented as mean±standard deviation.

[c]Mean gross energy difference not significantly different from 0 kcal (P=0.44).