Greenhouse gas emissions and energy use associated with production of individual self-selected U.S. diets

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SUPPORTING INFORMATION

- The complete *dataFIELD* database is available via: http://css.umich.edu/page/datafield
- NHANES dataset with GHGE per person for day one diets, and accompanying documentation, will be available at: https://sph.tulane.edu/gchb/diet-environmental-impacts

Literature review of food LCA and additional details on database development 2
Literature search 2
Weight basis adjustments 2
Exclusion of “greenhouse vegetables” and “beef from dairy” 2
Table S1: Conversion factors to boneless weight for meats and seafood 3
Figure S1: Distribution of Food LCA literature review entries across geographic regions. 4
LCA boundary conditions 4
Inedible portions 4
Additional food processing estimates 4
Impact factor variability estimate methods 5
Supplemental Results 6
Figure S2. Distribution across the U.S. population of diet-related CED per person per day, including both retail and consumer level food losses. Also shown is the influence of low and high cases in food impact factor variability. 6
Table S2. Contributions by food groups to diet-level impacts of 1-day diets for the total population and for those ranked at the lower and higher quintile by CED. 7
Food loss contributions in context 8
Influence of boundary conditions on results 8
Description of approach used to estimate food processing and packaging contributions via USEEIO 8
Table S3. NAICS sectors directly considered in USEEIO calculations. Lines shaded grey are those processing contributions assumed to be already captured in FCID assignments. 9
Description of 5th quintile diet shift calculations 11
Supporting Information References 11
Table S4. Listing of FCID foods and impact factors utilized in diet-level calculations.......... 14
References included in *dataFIELD* 23

Literature review of food LCA and additional details on database development

Literature search

We conducted a systematic search in Web of Science and Google Scholar databases. Search terms included combinations of "LCA" and "life cycle" with "food". Further refined searches targeted individual underrepresented foods. In addition, collected citations were cross-referenced with the extensive review by Clune et al. [1] and relevant additional citations were included. The literature review was limited to reports available in the public domain. Articles and reports written in English and published in 2005-2016 that applied LCA methods to one or more food products and provided primary (i.e., not cited from elsewhere) mid-point impact assessment of GHGE and/or CED were reviewed and inventoried. Peer reviewed journal articles as well as thoroughly documented reports from governmental and non-governmental organizations (including theses) were considered. Agricultural crops not expressly grown as human food (e.g., biofuels, timber, fibers) were excluded, as were Environmental Product Declarations (http://www.environdec.com/). Data collected from the literature review were logged into separate "entries," with each representing a unique food–production scenario combination (e.g. tomatoes grown conventionally in-field in Florida, U.S.). Multiple entries often existed from the same article. The full listing of references included in *dataFIELD* are included on page 22 of this Supporting Information document.

The majority of the publications inventoried were peer reviewed journal articles (64%); NGO reports, databases, industry-based reports, government reports, and conference proceedings represented 13%, 8%, 7%, 4%, and 2%, respectively. More than 63% of the recorded entries are based on food production in Europe (including the British Isles and Nordic countries) and there is very limited representation from South America, Asia and Africa. Only 12% of entries were from North America. Figure S1 shows the geographic distribution of food LCA entries recorded in *dataFIELD*.

Weight basis adjustments

For database consistency, mid-point indicator values were adjusted to a functional unit of "kg of food," with meat and fish/seafood adjusted to "kg of edible boneless weight". For most entries, this adjustment was minor (e.g., converting from ton to kg, or from L to kg using a reported density); meat and fish entries reported as live weight or carcass weight were adjusted to a boneless edible basis using conversion factors provided by the USDA, FAO, and other sources, as detailed in Table S1.

Exclusion of "greenhouse vegetables" and "beef from dairy"

There is little reliable information to weight average beef impacts by market share distribution between dedicated beef operations and beef from dairy operations, so studies on beef from dairy were excluded from the average of literature-based impact factors. One recent estimate suggests that between 11% and 20% of *ground* beef in the U.S. originates from a dairy herd, with ground beef representing 30-50% of total beef in the U.S. market [2]. Assuming that all beef from dairy goes to ground beef (as Goldstein *et al* do) and using a "beef from dairy" GHGE value of 19.0 kg CO_2eq/kg edible boneless beef (n=10), these market share estimates reduce the average GHGE value for beef (33.1 kg CO_2eq/kg in our study) to between 30.3 and 32.6 kg CO_2eq/kg (a 4.2% and 1.4% reduction), which is within the 95% confidence interval used to represent variability (30.6 – 35.6 kg CO_2eq/kg).

The impact of omitting studies on the greenhouse (hothouse) production of vegetables is unknown. Differences in impact factors are significant (e.g., 3.4 kg CO_2eq/kg greenhouse tomatoes vs. 0.43 kg CO_2eq/kg field-grown tomatoes) but data on market share is unreliable. Domestic hothouse vegetables are not included in official USDA annual production estimates, but allowances are made for them in ERS consumption statistics[1]. In calendar year 2011, protected-culture tomatoes made up 40

[1] https://www.ers.usda.gov/topics/crops/vegetables-pulses/tomatoes.aspx

percent of the U.S. tomato supply, up from less than 10 percent in 2004[2]. However, these statistics include a wide range of "protected culture" production methods, many of which do not include supplemental heat, the main driver of higher impacts of greenhouse production. Data for greenhouse production of lesser vegetables (peppers, melons) is even scarcer. Given these uncertainties, LCA studies on greenhouse production of vegetables were excluded from our calculated averages.

Table S1: Conversion factors to boneless weight for meats and seafood

	Live: carcass weight	Carcass: boneless weight	Live: boneless weight	Citation
Beef	1: 0.602	1:0.667	1:0.402	[3]
Sheep	1:0.508	1:0.658	1:0.334	[3]
Pork	1:0.724	1:0.729	1:0.528	[3]
Chicken	1:0.70	1:0.77	1:0.539	[4]
Turkey			1:0.56	[5]
Duck		1:0.45		[6]
Rabbit		1:0.795		[7]
Emu		1:0.325		[8]
Farmed trout			1:0.65	[9]
Farmed salmon			1:0.72	[10]
Farmed sea bass	1:0.68	1:0.65	1:0.44	[11]
Farmed turbot			1:0.48	[12]
Farmed tilapia			1:0.37	[13]
Farmed African catfish			1:0.65	[13]
Horse Mackerel			1:0.52	[13]
Tuna			1:0.58	[13]
Shrimp			1:0.57	[13]
Lobster			1:0.31	[14]
Octopus			1:0.79	[13]

[2] https://www.ers.usda.gov/amber-waves/2013/february/protected-culture-technology-transforms-the-fresh-tomato-market/

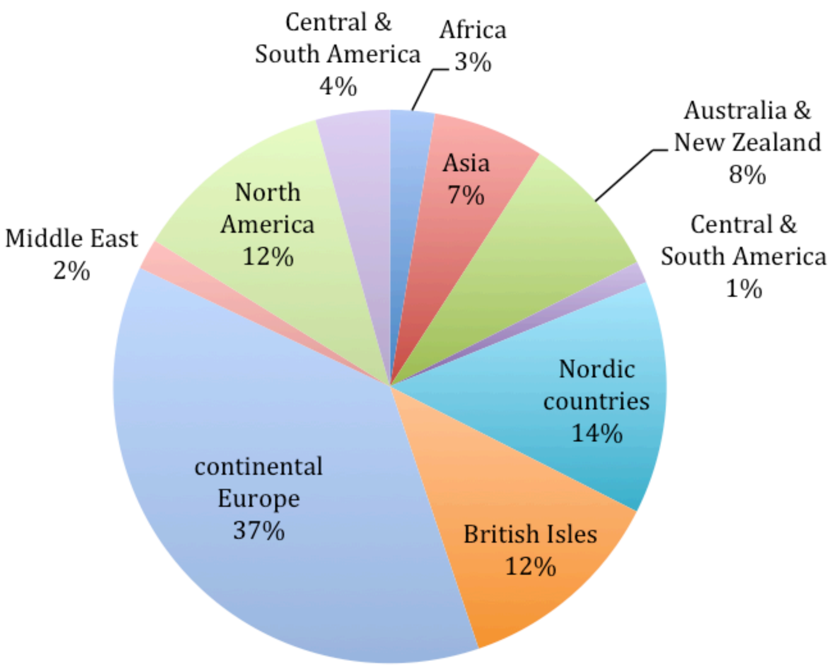


Figure S1: Distribution of Food LCA literature review entries across geographic regions.

LCA boundary conditions

Since we were considering commodity foods that, in many cases, become ingredients in processed, as-consumed foods, inclusion of life cycle stages downstream from the farm gate would not necessarily represent the actual foods consumed. The exceptions to this farm gate boundary condition are foods within the FCID listing that require processing: flours, refined sugars and molasses, chocolate and cocoa powder, vegetable oils, roasted and instant coffee, instant and dried teas, corn milling products, wine, fruit juices, peanut butter, potato chips, soy milk, and processed tomatoes. For these, life cycle impacts were cropped at a cradle-to-processor gate boundary condition. Packaging, distribution, retail, and consumer level impacts were not included in this analysis. Meats were left at a cradle-to-farm gate boundary condition despite the need for processing (slaughtering) due to the overwhelming number of studies that only report farm-gate impacts and a recognition that processing represents a minor contribution (slaughtering increased GHGE by 5% over farm gate values, on average, across all meat entries reporting processing in our literature review).

Inedible portions

The FCID database typically uses a weight basis that excludes inedible refuse (skins, peels, pits, seeds) whereas the weight basis common in LCA studies is an as-delivered or as-purchased form (e.g., whole apples, bananas with peels). To reconcile this inconsistency, we applied conversion factors drawn from various nutritional databases [3, 15-17]. For example, the GHGE and CED factors for bananas on an as-purchased basis are multiplied by 1.56 (conversion factor from Appendix B of [15]) to provide impact factors on a "pulp excluding peel" basis.

Additional food processing estimates

Lack of literature data for life cycle CED and GHGE for certain processed foods contained in the FCID listing required a combination of proxy data and other sources to develop valid estimates. Specifically, data on orange juice processing from Sanjuan et al. [18] were used as a proxy for all fruit and vegetable juices to estimate the processing energy required to convert fruits and vegetables into juiced form (e.g., apples to apple juice). Mass conversion factors (stage 4 proxy assignments in Table 6) were first applied to the impacts for producing the base fruit or vegetable. Then, energy demands from Sanjuan et al. were added to account for the energy required for washing, squeezing, and pasteurization. The calculated GHGE for each fruit juice included both the impact at the farm gate (mass adjusted to juice yield) and emissions associated with the processing energy requirements, assuming U.S. average grid electricity (emission factors derived from USLCI dataset [19], 2010 U.S. grid, IPCC 2013 GWP 100a).

Vinegar was assumed to use unpasteurized apple juice as its base ingredient and undergo processing in the form of fermentation and a fetter procedure. Apple juice impacts were calculated using the above method, with additional electricity requirements for fermentation and fettering provided by Sanjuan et al. [18]. Transmission and distribution losses were added to reported electrical energy needs (USLCI dataset [19], 2010 U.S. average grid, evaluated with method: Cumulative Energy Demand v1.09). As above, total GHGE were calculated using assumed average grid emission factors.

LCA data for maple syrup production were not identified, so secondary sources were used to generate estimates for energy used in production. Survey-based data from University of Wisconsin indicates that the average maple syrup energy use for non-wood fueled boilers was 331,000 BTU/ gallon of syrup produced [20], resulting in an estimated energy input of 69.3 MJ / kg maple syrup. Assuming residual fuel oil as a fuel source, GHGE associated with maple syrup production was calculated as 6.8 kg CO_2-eq/kg syrup.

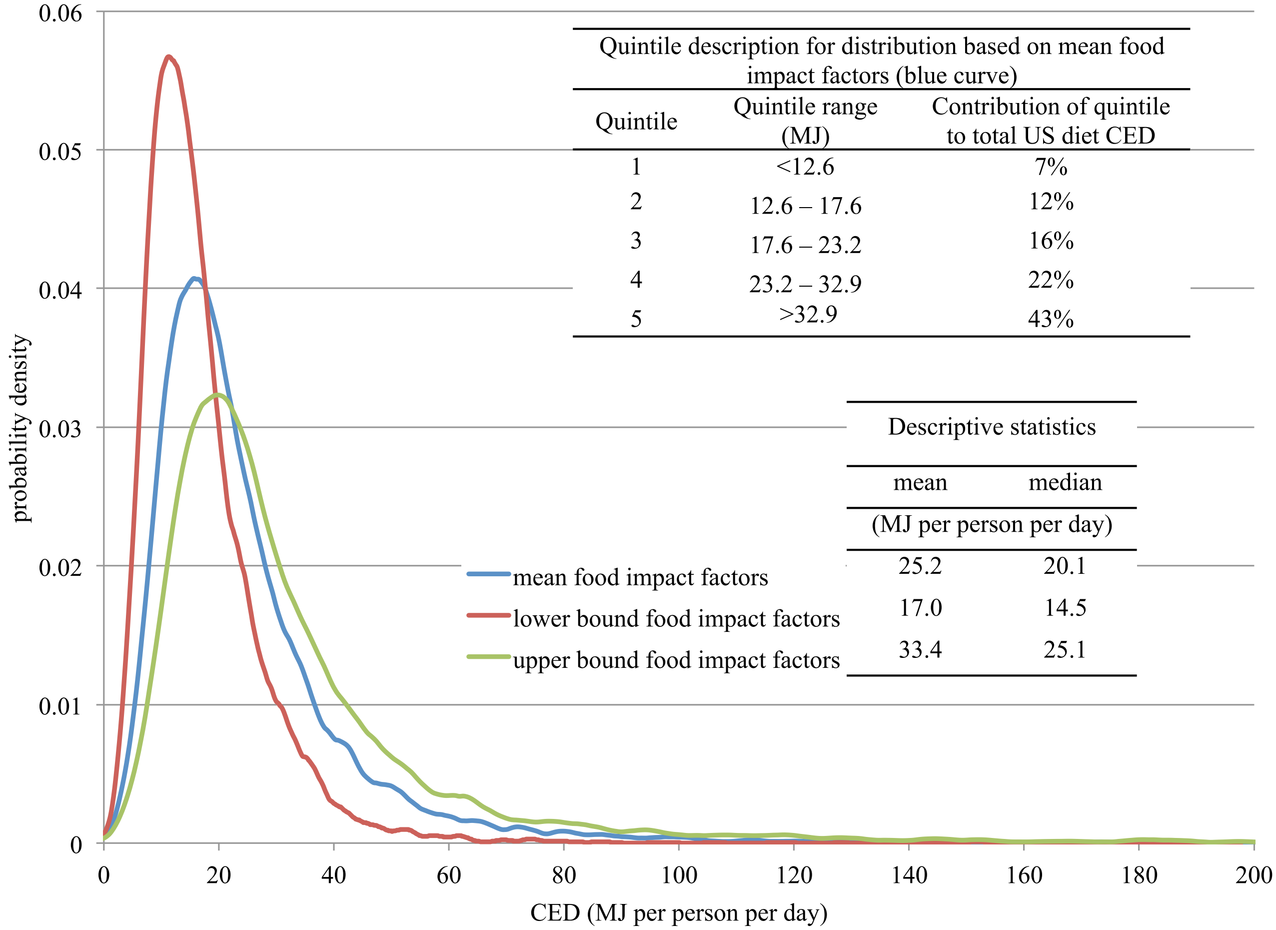
Impact factor variability estimate methods

We use the following approach to characterize variability in impact factors due to food production locations and practices as well as LCA methods, and then estimate its influence on the impacts of diet.

1. For both GHGE and CED, the number of datapoints ($n_{x,y}$, where x=*FCID food* and y=*GHGE or CED*) in *dataFIELD* used to construct the mean ($\bar{x}_{x,y}$) is evaluated. If $n_{x,y} \geq 5$, then the standard deviation ($SD_{x,y}$) for the individual food is used directly.
2. If the FCID food is assigned a proxy as per Table 6, and that proxy has $n_{x,y} \geq 5$, then $SD_{x,y}$ for the proxy (individual food or proxy group) is used.
3. For all FCID foods (proxied or not), if $\bar{x}_{x,y}$ is based on fewer than 5 observations ($n_{x,y} < 5$), then the standard deviation of a broader proxy group is used. For example, for x="chicory tops" there are no LCA studies ($n_{x,y}$=0), so the proxy "escarole" ($n_{\text{escarole},GHGE}$=3, $n_{\text{escarole},CED}$=3) is assigned (per stage 3 in Table 6) to calculate the mean ($\bar{x}_{\text{chicory tops},y}$). Since that proxy has less than 5 observations, the broader proxy group "greens" ($n_{\text{greens},GHGE}$=23, $n_{\text{greens},CED}$=11) is then assigned to calculate $SD_{\text{chicory tops},y}$. This broader group *SD* is then divided by the group mean and multiplied by the specific food mean ($\bar{x}_{x,y}$) in order to adjust the proxied *SD* to the scale of the specific food.
4. In a limited number of cases, no appropriate grouping could be assigned and the variance was assumed to be zero. These cases include dried ginseng, soy milk, grape wine and sherry ($SD_{x,CED}$ only), corn starch, corn syrup, cinnamon, coriander seed, dill seed, black and white pepper, other spices, and game meat.
5. In some cases, a cradle-to-processor gate boundary condition is used for calculating $\bar{x}_{x,y}$, but the broader assigned proxy group only contains sufficient data at the cradle-to-farm gate boundary condition. In these instances, it is assumed that the variability derives predominantly from on-farm production, and $SD_{x,y}$ is calculated with cradle-to-farm gate data.

After a standard deviation for each food impact was assigned, we calculated a 95% confidence interval around the average impact for that food $\left(\bar{x}_{x,y} \pm 1.96 \frac{SD_{x,y}}{\sqrt{n_{x,y}}}\right)$ and used the lower and upper bounds of this interval in subsequent calculations of diet-level variability.

Supplemental Results



Quintile description for distribution based on mean food impact factors (blue curve)

Quintile	Quintile range (MJ)	Contribution of quintile to total US diet CED
1	<12.6	7%
2	12.6 – 17.6	12%
3	17.6 – 23.2	16%
4	23.2 – 32.9	22%
5	>32.9	43%

Descriptive statistics	
mean	median
(MJ per person per day)	
25.2	20.1
17.0	14.5
33.4	25.1

Figure S2. Distribution across the U.S. population of diet-related CED per person per day, including both retail and consumer level food losses. Also shown is the influence of low and high cases in food impact factor variability.

Table S2. Contributions by food groups to diet-level impacts of 1-day diets for the total population and for those ranked at the lower and higher quintile by CED.

	% contribution to total CED[1]			Sum of CED per day[1] (TJ per day)[2]		
	Total population	1st quintile	5th quintile	Total population	1st quintile	5th quintile
Meats	29.7	27.1	25.5	1665.7	112.0	611.3
Dairy	18.8	23.8	13.4	1053.6	98.5	322.6
Beverages	16.0	18.1	14.4	896.1	74.9	344.5
Fish and Seafood	17.9	1.3	35.6	1006.8	5.5	854.9
Eggs	3.3	4.3	2.4	182.7	17.7	58.7
Vegetables	3.8	6.3	2.4	210.6	25.9	57.6
Cereals and Grains	2.5	5.1	1.5	142.9	21.0	35.8
Fruits	2.3	4.5	1.2	131.8	18.8	29.4
Sweeteners	2.6	4.3	1.6	146.1	17.9	39.4
Other	0.8	1.1	0.5	46.0	4.7	11.8
Oils and Fats	1.6	2.7	1.0	88.3	11.3	24.3
Nuts and seeds	0.4	0.6	0.2	21.8	2.6	5.8
Legumes	0.3	0.7	0.2	18.0	3.0	4.2
Total diet				5610.3	413.6	2400.2

[1]Environmental impacts (including retail and consumer losses) for specific foods were summed within each broad food group for each individual (based on NHANES 2005-2010 24-hour diet recall, adults aged 18 and over; N=16,800), and then aggregated across all individuals in the relevant category (total population, 1st quintile, or 5th quintile).

[2] 1TJ = 10^6 MJ = 10^{12} Joules

Food loss contributions in context

Food losses are an important factor in estimating environmental impact of diets as foods produced but not eaten also contribute to overall system impact. Dietary recall data such as NHANES do not capture food losses/wastes, so here we have utilized food loss rates estimated by USDA. As can be seen in Tables 2 and 3, these losses represent 24-25% of the estimated impacts from producing the U.S. diet, slightly less than the 28% in our previous estimates [21]. The USDA and U.S. EPA have established a food waste reduction goal of 50% by 2030. If this 50% reduction were applied evenly across these NHANES diets, with the food loss estimates utilized here, it would amount to a reduction of 12% in food production GHGE, which is equivalent to eliminating 311 million average passenger vehicle miles[†] on a given day. If this were again implemented every day throughout the year, it would represent an additional 4.5% of the necessary reductions to meet the UNFCCC target.

Influence of boundary conditions on results

The boundary conditions for the current study are cradle to farm gate for most food commodities, and include processing for the collection of FCID foods that are minimally processed ingredients (flours, oils, juices, etc). Many of these commodity foods are then linked through FCID recipe files to the as-consumed foods (often processed) that are reported in NHANES. Thus, due to the lack of specific LCA data for the inordinate number of as-consumed foods in the U.S. diet, our reported values should be considered underestimates of actual impacts associated with food consumption in the U.S. as they include the production impacts of processed food ingredients, but not the impacts of processing itself. To approximate the magnitude of these missing food processing impacts, we have utilized USEEIO, the newly developed U.S. environmentally extended input-output model from U.S. EPA [22]. Through a top-down approach detailed below, we estimate that food processing not captured in our bottom-up estimates amounts to 15% of the total cradle to processor gate (including agricultural production sectors) GHGE. Packaging materials represent an additional 6%. Inclusion of these missing food processing and packaging contributions would raise our estimates by ~27%, although it is important to note that these input-output based approximations are made for the food and agricultural sectors in aggregate, and will not apply evenly across different food types or for specific diets (i.e., they apply only at the mean). The USEEIO model currently does not contain distribution or wholesaling and retailing sectors, so these contributions could not be estimated. Using the EIO-LCA model, Weber and Matthews [23] previously demonstrated that delivery (distribution) of final products accounted for 4% of the GHGE associated with U.S. household food consumption, whereas wholesaling and retailing of food accounted for an additional 5%.

Description of approach used to estimate food processing and packaging contributions via USEEIO

Environmentally extended input-output (EEIO) analysis and the USEEIO model developed by US EPA have been sufficiently described elsewhere [22]. In this application, we focus on the sectors listed in Table S3 (note that contributions from underlying sectors are included in deriving emission factors for the described sectors). Our goal is to estimate the farm-gate to processor gate emissions *not* captured in our bottom up, process LCA approach.

First, emission factors (E_{A+P} in kg CO_2 eq per \$ spent, 2013 US dollars) were derived for all agricultural and food processing sectors. Second, the agricultural sectors were artificially "zeroed" in the IO matrix, and emission factors (E_P^{-ag}) were again derived for food processing sectors, in essence giving the post-farm gate contributions to food processing. This approach is critical because agricultural sectors contribute directly to food processing sectors (e.g., 'breakfast cereals' has contributions from 'grain farming') but also indirectly (e.g., 'breakfast cereals' has contributions 'fruit and vegetable preservation', such as raisins, which in turn has direct farming contributions). Third, as packaging materials are included within the cradle-to-processor gate boundary conditions of USEEIO and our bottom-up boundary conditions exclude packaging, we make a coarse estimate of the contribution from packaging materials by again zeroing out the packaging materials sectors listed in Table S3 (along with the agricultural sectors) and deriving emission factors ($E_P^{-ag\text{-}pkg}$) for food processing sectors. This provides an estimate of food processing emissions without agricultural and packaging materials contributions.

Next, the agricultural and food processing emission factors were multiplied by a final demand vector, k, represented by 2007 personal expenditure data [24] to arrive at total emissions associated with each sector, m_{A+P}, which can then be summed to provide a total cradle-to processor gate food systems emissions.

$$\Sigma\, m_{A+P} = E_{A+P}k \tag{1}$$

where A+P = all agricultural and food processing sectors in Table S3

Note that this is not technically correct as the years represented in the IO vector and the expenditure data are not the same, but for the purposes of this exercise where we are only expressing results in relative terms, it is a sufficient estimate.

To get at the missing food processing contributions, we multiply $E_P^{-ag\text{-}pkg}$ by k. However, *some* commodity processing is being captured in our process-based estimates (flours, refined sugars and molasses, chocolate and cocoa powder, vegetable oils, roasted and instant coffee, instant and dried teas, corn milling products, wine, fruit juices, peanut butter, potato chips, soy milk, and processed tomatoes; see “LCA Boundary Conditions” section above); the already captured processing is assumed to be represented by the shaded sectors in Table S3. Certain commodity processing, such as fruit juices, are not easily disaggregated within the NAICS sector designation; frozen fruit juices are included in NAICS 311410 whereas canned juices are included in NAICS 311420. Such inability to disaggregate represents an error in the top-down approach.

$$\Sigma\, m_{P^*} = E_{P^*}^{-ag-pkg}k \tag{2}$$

where P^*= the non-shaded food processing sectors in Table S3

The ratio of the sum from equation 2 to equation 1 then gives a sense of the percentage of total US cradle-to-processor gate emissions that are *not* captured in the bottom-up approach described in this paper, which we calculate to be 15%. We emphasize the importance of representing this in relative terms as the two approaches (top-down, economy-wide EEIO vs. bottom-up, individual-diet process-based) are not directly compatible. However, in the absence of process-based data for the large number of processed food products on the market, this approach offers a reasonable means of placing some bounds on the contribution from this processing.

As our process-based boundary conditions also exclude food packaging, we use USEEIO to give an indication of their magnitude as well. The difference between food processing sector emission factors without agriculture and food processing sector emission factors without agriculture *and* packaging provides and indication of the contribution from packaging. Again, this is not precise, as food packaging materials likely extend beyond the packaging sectors considered (indicated by those sectors in red font in Table S3), and there are contributions beyond the packaging materials themselves, but it provides a rough indication of magnitude. Here, the sum is over all food processing sectors, as our process-based approach excludes all packaging.

$$\Sigma\, m_P = \left(E_P^{-ag} - E_P^{-ag-pkg}\right)k \tag{3}$$

The ratio of the sum from Equation 3 to that of Equation 1 provides the percent contribution from packaging, here calculated as 6%.

Table S3. NAICS sectors directly considered in USEEIO calculations. Lines shaded grey are those processing contributions assumed to be already captured in FCID assignments.

agricultural sectors	
NAICS code	
1111a0	oilseed farming
1111b0	grain farming
111200	vegetable and melon farming

111300	fruit and tree nut farming
111400	greenhouse, nursery, and floriculture production
111900	other crop farming
1121a0	beef cattle ranching and farming, including feedlots and dual-purpose ranching and farming
112120	dairy cattle and milk production
112a00	animal production, except cattle and poultry and eggs
112300	poultry and egg production
113000	forestry and logging
114000	fishing, hunting and trapping
115000	support activities for agriculture and forestry
food processing sectors	
311210	flours and malts
311221	corn products
311225	refined vegetable, olive, and seed oils
31122a	vegetable oils and by-products
311230	breakfast cereals
311300	sugar, candy, and chocolate
311410	frozen food
311420	fruit and vegetable preservation
311513	cheese
311514	dry, condensed, and evaporated dairy
31151a	fluid milk and butter
311520	ice cream and frozen desserts
311615	packaged poultry
31161a	packaged meat (except poultry)
311700	seafood
311810	bread and other baked goods
3118a0	cookies, crackers, pastas, and tortillas
311910	snack foods
311920	coffee and tea
311930	flavored drink concentrates
311940	seasonings and dressings
311990	all other foods
312110	soft drinks, bottled water, and ice
312120	breweries and beer
312130	wineries and wine
312140	distilleries and spirits
packaging materials	
322210	Paperboard container manufacturing
32222A	Coated and laminated paper, packaging
32222B	All other paper bag and coated and treated paper manufacturing

326110	Plastics packaging materials, film and sheet
326160	Plastics bottle manufacturing
327213	Glass container manufacturing
332430	Metal can, box, and other container

Description of 5th quintile diet shift calculations

The emissions associated with the top quintile of the diets, representing 44.6 million Americans in our study, amounts to 0.48 million metric tons CO_2 eq. (mmt) on a given day (average emission for 5th quintile = 10.74 kg CO_2 eq. person^{-1} day^{-1}). Shifting this quintile to diets with an average emission (4.72 kg CO_2 eq. person^{-1} day^{-1}) represents a reduction in emissions of 0.2685 mmt. While these diets are representative of the U.S. population on a given day, if we assume that they emulate "usual" diets and implement this shift every day, the annual emissions reduction would be 98.0 mmt.

The US Intended Nationally Determined Contribution to the United Nations Framework Convention on Climate Change states that "the United States intends to achieve an economy-wide target of reducing its greenhouse gas emissions by 26-28 per cent below its 2005 level in 2025."
[http://www4.unfccc.int/Submissions/INDC/Published%20Documents/United%20States%20of%20America/1/U.S.%20Cover%20Note%20INDC%20and%20Accompanying%20Information.pdf]

According to the "US EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2015" [https://www.epa.gov/sites/production/files/2017-02/documents/2017_executive_summary.pdf],
2005 net emissions equaled 6582.3 mmt CO_2 eq., making a reduction of 27% from this baseline an annual net emissions below 4805.1 mmt.
2015 net emissions (considered present in this calculation) = 5827.7 mmt. Thus, the reduction required from 2015 emissions to meet the target = 1022.6 mmt.

Thus, the savings represented by shifting the 5th quintile to an average emission diet = 98.0/1022.6 = 9.6% of the required reduction to meet the target.

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Table S4. Listing of FCID foods and impact factors utilized in diet-level calculations.

		GHGE	CED		
FCID_Code	FCID_Desc	CO_2 eq / kg	MJ / kg	farm gate (=1) or processor gate (=2)?	PROXY DEFINITION
101050000	Beet, garden, roots	0.194	1.221	1	
101052000	Beet, sugar	0.391	4.574	2	
101053000	Beet, sugar, molasses	0.288	3.476	2	
101067000	Burdock	0.284	1.891	1	roots
101078000	Carrot	0.092	1.326	1	
101079000	Carrot, juice	1.071	6.608	1	carrot
101100000	Chicory, roots	0.050	0.154	1	
101168000	Ginseng, dried	0.870	0.000	1	spices
101190000	Horseradish	0.213	1.422	1	roots
101251000	Parsnip	0.243	1.621	1	roots
101314000	Radish, roots	0.237	1.578	1	roots
101316000	Radish, Oriental, roots	0.271	1.806	1	roots
101327000	Rutabaga	0.252	1.678	1	roots
101388000	Turnip, roots	0.498	1.749	1	roots
103015000	Arrowroot, flour	0.079	0.625	1	cassava
103017000	Artichoke, Jerusalem	0.544	4.028	1	potato
103082000	Cassava	0.079	0.625	1	
103139000	Dasheen, corm	0.213	1.422	1	roots
103166000	Ginger	0.950	1.536	1	roots
103167000	Ginger, dried	0.977	6.513	1	roots
103296000	Potato, chips	1.545	19.750	2	
103297000	Potato, dry (granules/ flakes)	1.309	9.700	1	potato
103298000	Potato, flour	0.953	6.631	2	
103299000	Potato, tuber, w/peel	0.217	1.611	1	
103300000	Potato, tuber, w/o peel	0.216	2.143	1	potato
103366000	Sweet potato	0.302	2.240	1	potato
103371000	Tanier, corm	0.213	1.422	1	roots
103387000	Turmeric	0.213	1.422	1	roots
103406000	Yam, true	1.021	1.869	1	potato
103407000	Yam bean	0.237	1.756	1	potato
200051000	Beet, garden, tops	0.322	4.257	1	greens

200101000	Chicory, tops	0.064	1.215	1	Escarole
200140000	Dasheen, leaves	0.180	2.378	1	greens
301165000	Garlic, bulb	0.743	2.932	1	onion_bulb
301237000	Onion, bulb	0.269	2.830	1	
301238000	Onion, bulb, dried	2.102	22.152	1	onion_bulb
301338000	Shallot, bulb	0.275	2.896	1	onion_bulb
302103000	Chive, fresh leaves	0.221	1.551	1	spinach
302198000	Leek	0.069	2.550	1	onion_bulb
302239000	Onion, green	0.085	1.231	1	carrot
401005000	Amaranth, leafy	0.180	2.378	1	greens
401118000	Cilantro, leaves	0.261	1.830	1	spinach
401138000	Dandelion, leaves	0.056	1.060	1	Escarole
401144000	Dillweed	0.221	1.551	1	spinach
401150000	Endive	0.065	1.230	1	Escarole
401204000	Lettuce, head	0.158	2.084	1	
401205000	Lettuce, leaf	0.220	3.514	1	
401248000	Parsley, leaves	0.232	1.628	1	spinach
401313000	Radicchio	0.061	1.166	1	Escarole
401355000	Spinach	0.307	2.156	1	
401367000	Swiss chard	0.196	2.592	1	greens
402018000	Arugula	0.300	3.971	1	greens
402062000	Broccoli, Chinese	0.486	4.291	1	broccoli
402070000	Cabbage, Chinese, bok choy	0.134	0.527	1	brassica_greens
402117000	Collards	0.206	0.809	1	brassica_greens
402133000	Cress, garden	0.253	3.353	1	greens
402194000	Kale	0.193	0.758	1	
402229000	Mustard greens	0.127	0.499	1	brassica_greens
402389000	Turnip, greens	0.168	0.660	1	brassica_greens
402398000	Watercress	0.196	2.592	1	greens
500061000	Broccoli	0.797	7.037	1	
500064000	Brussels sprouts	0.490	4.185	1	brassica
500069000	Cabbage	0.219	1.375	1	
500071000	Cabbage, Chinese, napa	0.134	0.527	1	brassica_greens
500072000	Cabbage, Chinese, mustard	0.127	0.499	1	brassica_greens
500083000	Cauliflower	0.934	4.404	1	
600347000	Soybean, seed	1.154	2.716	1	
600348000	Soybean, flour	0.406	2.963	2	soybean_meal
600349000	Soybean, soy milk	0.258	1.683	2	
600350000	Soybean, oil	0.807	7.616	2	
601043000	Bean, snap, succulent	0.754	5.786	1	
601257000	Pea, edible podded, succulent	0.701	5.380	1	Bean_snap_succulent

602031000	Bean, broad, succulent	0.662	5.075	1	Bean_snap_succulent
602033000	Bean, cowpea, succulent	0.662	5.075	1	Bean_snap_succulent
602037000	Bean, lima, succulent	0.662	5.075	1	Bean_snap_succulent
602255000	Pea, succulent	1.330	3.500	1	
602259000	Pea, pigeon, succulent	1.054	3.227	1	Pea_pigeon_seed
603030000	Bean, black, seed	0.308	4.756	1	bean_dry
603032000	Bean, broad, seed	1.168	4.756	1	bean_dry
603034000	Bean, cowpea, seed	0.610	4.756	1	bean_dry
603035000	Bean, great northern, seed	0.308	4.756	1	bean_dry
603036000	Bean, kidney, seed	0.308	4.756	1	bean_dry
603038000	Bean, lima, seed	0.308	4.756	1	bean_dry
603039000	Bean, mung, seed	1.880	1.320	1	lentil_seed
603040000	Bean, navy, seed	0.308	4.756	1	bean_dry
603041000	Bean, pink, seed	0.308	4.756	1	bean_dry
603042000	Bean, pinto, seed	0.308	4.756	1	bean_dry
603098000	Chickpea, seed	0.491	1.543	1	
603182000	Guar, seed	1.400	1.320	1	lentil_seed
603203000	Lentil, seed	1.880	1.320	1	
603256000	Pea, dry	0.617	3.647	1	
603258000	Pea, pigeon, seed	1.054	3.227	1	
801374000	Tomatillo	0.470	2.629	1	tomato
801375000	Tomato	0.470	2.629	1	
801376000	Tomato, paste	0.118	1.438	2	
801377000	Tomato, puree	1.147	10.581	2	
801378000	Tomato, dried	7.304	40.826	1	tomato
801379000	Tomato, juice	0.153	2.556	2	
802148000	Eggplant	0.526	2.940	1	nightshades
802234000	Okra	0.496	2.773	1	nightshades
802270000	Pepper, bell	0.525	6.881	1	
802271000	Pepper, bell, dried	5.245	68.797	1	pepper_bell
802272000	Pepper, nonbell	0.799	6.824	1	pepper_bell
802273000	Pepper, nonbell, dried	4.362	57.218	1	pepper_bell
901075000	Cantaloupe	0.490	2.862	1	melon
901187000	Honeydew melon	0.284	3.168	1	
901399000	Watermelon	1.946	2.803	1	melon
901400000	Watermelon, juice	2.293	8.085	1	melon
902021000	Balsam pear	0.397	0.840	1	cucumber
902088000	Chayote, fruit	0.397	0.840	1	cucumber
902102000	Chinese waxgourd	0.147	2.045	1	squash
902135000	Cucumber	0.409	0.865	1	
902308000	Pumpkin	0.218	2.746	1	

902309000	Pumpkin, seed	0.103	1.440	1	squash
902356000	Squash, summer	1.229	0.193	1	zucchini
902357000	Squash, winter	0.063	1.354	1	
1001106000	Citron	0.593	5.277	1	citrus
1001107000	Citrus hybrids	0.400	3.562	1	citrus
1001240000	Orange	0.294	3.726	1	
1001241000	Orange, juice	0.509	5.573	2	
1001242000	Orange, peel	0.214	2.720	1	orange
1001369000	Tangerine	0.400	3.562	1	citrus
1001370000	Tangerine, juice	1.572	10.559	1	citrus
1002197000	Kumquat	0.320	2.849	1	citrus
1002199000	Lemon	0.422	4.678	1	
1002200000	Lemon, juice	0.332	6.000	2	
1002201000	Lemon, peel	0.297	2.638	1	citrus
1002206000	Lime	0.612	3.166	1	citrus
1002207000	Lime, juice	1.943	13.857	1	citrus
1003180000	Grapefruit	1.210	5.277	1	citrus
1003181000	Grapefruit, juice	1.646	11.218	1	citrus
1100007000	Apple, fruit with peel	0.228	1.595	1	
1100008000	Apple, peeled fruit	0.267	1.868	1	apple
1100009000	Apple, dried	1.265	8.839	1	apple
1100010000	Apple, juice	1.288	7.438	1	apple
1100011000	Apple, sauce	0.288	2.012	1	apple
1100266000	Pear	0.249	2.922	1	
1100267000	Pear, dried	1.121	13.160	1	pear
1100268000	Pear, juice	1.315	9.230	1	pear
1201090000	Cherry	0.510	4.360	1	
1201091000	Cherry, juice	1.587	10.482	1	cherry
1202012000	Apricot	0.464	2.195	1	tree_fruit
1202013000	Apricot, dried	1.408	11.095	1	tree_fruit
1202014000	Apricot, juice	1.399	8.594	1	tree_fruit
1202230000	Nectarine	0.284	2.235	1	tree_fruit
1202260000	Peach	0.274	2.897	1	
1202261000	Peach, dried	1.678	17.775	1	peach
1202262000	Peach, juice	1.408	9.823	1	peach
1203285000	Plum	0.576	2.154	1	tree_fruit
1203286000	Plum, prune, fresh	0.273	2.154	1	tree_fruit
1203287000	Plum, prune, dried	1.478	11.643	1	tree_fruit
1203288000	Plum, prune, juice	1.399	8.594	1	tree_fruit
1301055000	Blackberry	0.599	6.475	1	berry
1301056000	Blackberry, juice	1.728	13.375	1	berry
1301058000	Boysenberry	0.599	6.475	1	berry

1301320000	Raspberry	0.237	5.328	1	
1301321000	Raspberry, juice	1.555	11.508	1	berry
1302057000	Blueberry	0.496	3.510	1	
1302137000	Currant, dried	0.684	28.264	1	grape_raisin
1302174000	Gooseberry	0.840	6.226	1	berry
1302191000	Huckleberry	0.605	6.537	1	berry
1303227000	Mulberry	0.599	6.475	1	berry
1304175000	Grape	0.478	2.810	1	
1304176000	Grape, juice	1.576	8.795	1	Grape
1304178000	Grape, raisin	0.684	28.264	1	
1304179000	Grape, wine and sherry	0.780	7.674	2	beer
1304195000	Kiwifruit, fuzzy	0.264	6.310	1	
1307130000	Cranberry	1.418	6.350	1	berry
1307131000	Cranberry, dried	3.825	41.345	1	berry
1307132000	Cranberry, juice	1.728	13.375	1	berry
1307359000	Strawberry	0.614	8.289	1	
1307360000	Strawberry, juice	1.732	15.448	1	strawberry
1400003000	Almond	2.272	23.200	1	
1400004000	Almond, oil	2.272	23.200	1	almond
1400059000	Brazil nut	2.057	13.970	1	nut
1400068000	Butternut	2.057	13.970	1	nut
1400081000	Cashew	4.999	13.970	1	nut
1400092000	Chestnut	1.269	17.322	1	nut
1400111000	Coconut, meat	1.521	5.772	1	
1400112000	Coconut, dried	1.449	5.501	1	coconut_meat
1400113000	Coconut, milk	0.792	3.006	1	coconut_meat
1400114000	Coconut, oil	2.729	11.900	2	
1400155000	Hazelnut	0.990	28.400	1	
1400213000	Macadamia nut	2.057	13.970	1	nut
1400269000	Pecan	2.057	13.970	1	nut
1400278000	Pine nut	2.057	13.970	1	nut
1400282000	Pistachio	1.792	14.389	1	nut
1400391000	Walnut	1.657	13.970	1	nut
1500025000	Barley, pearled barley	0.393	2.584	1	grains
1500026000	Barley, flour	0.358	2.374	2	wheat_flour
1500027000	Barley, bran	0.393	2.584	1	grains
1500065000	Buckwheat	0.393	2.584	1	grains
1500120000	Corn, field, flour	0.550	5.800	2	
1500121000	Corn, field, meal	0.550	5.800	2	corn_flour
1500122000	Corn, field, bran	0.550	5.800	2	corn_flour
1500123000	Corn, field, starch	0.760	8.800	2	
1500124000	Corn, field, syrup	0.760	8.800	2	corn_starch

1500125000	Corn, field, oil	1.199	15.166	2	
1500126000	Corn, pop	0.393	2.584	1	grains
1500127000	Corn, sweet	0.757	6.642	1	
1500226000	Millet, grain	0.470	2.584	1	grains
1500231000	Oat, bran	0.498	4.686	2	oat_flour
1500232000	Oat, flour	0.498	4.686	2	
1500233000	Oat, groats/rolled oats	0.474	2.771	1	
1500323000	Rice, white	1.541	5.839	2	
1500324000	Rice, brown	2.175	6.687	1	
1500325000	Rice, flour	1.357	5.398	2	rice_bran
1500326000	Rice, bran	1.357	5.398	2	
1500328000	Rye, grain	0.385	2.696	1	
1500329000	Rye, flour	0.418	3.949	2	
1500345000	Sorghum, syrup	0.488	5.079	2	sugarcane_molasses
1500381000	Triticale, flour	0.358	2.374	2	wheat_flour
1500401000	Wheat, grain	0.347	2.235	1	
1500402000	Wheat, flour	0.358	2.374	2	
1500403000	Wheat, germ	0.358	2.374	2	wheat_flour
1500404000	Wheat, bran	0.358	2.374	2	wheat_flour
1500405000	Wild rice	1.852	6.223	1	rice
1800002000	Alfalfa, seed	6.250	8.240	1	clover_seed
1901028000	Basil, fresh leaves	0.221	1.551	1	spinach
1901029000	Basil, dried leaves	2.495	17.509	1	spinach
1901184000	Herbs, other	0.221	1.551	1	spinach
1901220000	Marjoram	0.221	1.551	1	spinach
1901249000	Parsley, dried leaves	1.692	11.875	1	spinach
1901334000	Savory	0.221	1.551	1	spinach
1902105000	Cinnamon	0.870	0.000	1	
1902119000	Coriander, seed	0.870	0.000	1	spices
1902143000	Dill, seed	0.870	0.000	1	spices
1902274000	Pepper, black and white	0.870	0.000	1	spices
1902354000	Spices, other	0.870	0.000	1	spices
2001162900	Flax, seed	0.393	2.584	1	grains
2001163000	Flax seed, oil	2.334	14.641	2	oilseed_oil
2001319000	Rapeseed, oil	2.275	13.328	2	
2001336000	Sesame, seed	1.050	2.584	1	grains
2001337000	Sesame, oil	2.334	14.641	2	oilseed_oil
2002330000	Safflower, oil	2.334	14.641	2	oilseed_oil
2002364000	Sunflower, seed	0.848	6.382	1	
2002365000	Sunflower, oil	2.646	5.794	2	
2003128000	Cottonseed, oil	2.140	24.800	2	
2100228000	Mushroom	3.093	4.987	1	

2201019000	Asparagus	2.171	20.181	1	
2201022000	Bamboo, shoots	1.149	10.678	1	asparagus
2201073000	Cactus	0.413	0.874	1	cucumber
2201152000	Fennel, Florence	0.331	5.881	1	celery
2201196000	Kohlrabi	0.958	8.181	1	brassica
2201243000	Palm heart, leaves	0.534	3.395	1	tropical_fruit
2202085000	Celery	0.331	5.881	1	
2202086000	Celery, juice	2.457	31.538	1	celery
2202322000	Rhubarb	1.528	14.201	1	asparagus
2301235000	Olive	0.482	6.637	1	
2301236000	Olive, oil	3.206	15.708	2	
2302077000	Carob	0.534	3.395	1	tropical_fruit
2302153000	Fig	0.540	3.429	1	tropical_fruit
2302154000	Fig, dried	1.807	11.476	1	tropical_fruit
2302183000	Guava	2.278	4.346	1	tropical_fruit
2302368000	Tamarind	1.571	9.983	1	tropical_fruit
2303141000	Date	2.024	21.075	1	
2401211000	Lychee	0.893	5.670	1	tropical_fruit
2402020000	Avocado	0.547	9.187	1	
2402023000	Banana	0.374	3.979	1	
2402024000	Banana, dried	1.448	15.406	1	banana
2402215000	Mango	0.639	4.923	1	tropical_fruit
2402216000	Mango, dried	2.695	17.121	1	tropical_fruit
2402217000	Mango, juice	1.984	11.665	1	tropical_fruit
2402245000	Papaya	0.216	1.980	1	
2402246000	Papaya, dried	1.551	14.218	1	papaya
2402247000	Papaya, juice	1.195	7.262	1	papaya
2402277000	Persimmon	0.307	2.418	1	tree_fruit
2402283000	Plantain	2.048	3.928	1	banana
2402284000	Plantain, dried	0.757	8.052	1	banana
2402289000	Pomegranate	0.462	3.637	1	tree_fruit
2402290000	Pomegranate, juice	1.902	12.556	1	tree_fruit
2403060000	Breadfruit	0.684	4.346	1	tropical_fruit
2403279000	Pineapple	0.914	5.619	1	
2403280000	Pineapple, dried	4.522	27.807	1	pineapple
2403281000	Pineapple, juice	1.855	10.671	1	pineapple
2403346000	Soursop	0.796	5.059	1	tropical_fruit
2405252000	Passionfruit	1.663	9.628	1	tropical_fruit
2405253000	Passionfruit, juice	1.005	6.383	1	tropical_fruit
3100044000	Beef	32.846	67.895	1	
3200169000	Goat	34.745	33.613	1	Sheep
3400290000	Pork	5.560	28.620	1	

3500339000	Sheep	34.745	33.613	1	
3600222000	Milk	1.323	7.129	2	
3800221000	Meat, game	0.840	8.500	2	
3900312000	Rabbit, meat	4.541	55.220	1	chicken
4000093000	Chicken, meat	4.188	27.338	1	
5000382000	Turkey, meat	2.571	27.338	1	chicken
6000301000	Poultry, other, meat	2.831	24.475	1	
7000145000	Egg	3.754	23.002	1	
8000157000	Fish-freshwater finfish	1.571	22.350	1	
8000158000	Fish-freshwater finfish, farm raised	5.717	157.432	1	
8000159000	Fish-saltwater finfish, tuna	2.148	32.180	1	saltwater_finfish
8000160000	Fish-saltwater finfish, other	3.021	130.894	1	
8000161000	Fish-shellfish, crustacean	30.658	321.071	1	
8000162000	Fish-shellfish, mollusc	3.143	172.822	1	all_fish
8601100000	Water, direct, tap	0.000	0.007	2	
8601200000	Water, direct, bottled	0.009	0.133	2	
8602000000	Water, indirect, all sources	0.000	0.000	1	
9500006000	Amaranth, grain	0.393	2.584	1	grains
9500016000	Artichoke, globe	0.846	16.925	1	asparagus
9500054000	Belgium endive	0.064	1.215	1	Escarole
9500109000	Cocoa bean, chocolate	11.250	86.122	1	
9500110000	Cocoa bean, powder	33.647	3.745	2	
9500115000	Coffee, roasted bean	6.279	64.581	2	
9500116000	Coffee, instant	19.200	181.250	2	
9500177000	Grape, leaves	0.180	2.378	1	greens
9500186000	Honey	2.440	3.450	2	
9500186100	Bee pollen	2.440	3.450	2	honey
9500188000	Hops	2.350	2.702	1	Grape
9500218000	Maple, sugar	9.186	94.336	2	Maple_syrup
9500219000	Maple syrup	6.754	69.365	2	
9500244000	Palm, oil	7.221	10.071	2	
9500263000	Peanut	0.374	1.090	1	
9500264000	Peanut, butter	1.132	2.963	2	soybean_meal
9500265000	Peanut, oil	4.656	3.158	2	
9500275000	Peppermint	0.221	1.551	1	spinach
9500276000	Peppermint, oil	2.729	11.900	2	coconut_oil
9500306000	Psyllium, seed	0.393	2.584	1	grains
9500335000	Seaweed	0.180	2.378	1	greens
9500362000	Sugarcane, sugar	0.700	5.146	2	
9500363000	Sugarcane, molasses	0.488	5.079	2	
9500372000	Tea, dried	3.820	53.431	2	

9500373000	Tea, instant	11.079	154.951	2	tea
9500390000	Vinegar	0.340	2.704	1	apple
9500397000	Water chestnut	0.277	1.849	1	roots
Directly linked	Beer	0.315	7.674		
Directly linked	Carbonated Drinks	0.066	2.760		
Directly linked	liquor	2.171			
Directly linked	Cheese, Cow	9.974	54.860		
Directly linked	Yogurt, Cow	1.330	9.691		
Directly linked	snail	0.7			
Directly linked	Tofu	1.664			

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