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Unpacking the Decline in Food Waste Measured in Chinese Households from 1991 to 2009

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Abstract

Food waste reduction is an explicit goal for many countries, yet a paucity of highquality primary measurements of food waste are available to inform policy. We analyze repeated physical measurements of discarded food from more than 37,000 households enrolled in the China Health and Nutrition Survey (CHNS) from 1991 to 2009 and describe relevant food waste patterns and trends within households over a period of dramatic change. Over a period in which average real household incomes tripled, food discarded per person declined by about 20% on a quantity basis and by about 40% on a Calorie basis during the study, with an estimated annual per capita household waste of 14.9 kg in 2009. Comparing across households within narrower periods of the data, we find changing associations between income and food waste, with a weakly negative association during the 1990s and a significant positive association during the 2000s. Carbohydrates, particularly grains and vegetables and fruits, experienced the greatest reduction in waste. Food waste reduction rates over the study period were greatest among small households and rural households. Certain characteristics were associated with higher per person waste levels throughout the study period, including rural residence, intense physical activity levels, and a lack of home refrigeration.

Keywords

Household food waste; economic growth; China; income; physical activity; refrigeration; food waste diaries; macronutrients; urban; rural

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Introduction

The reduction of food waste is an explicit goal for the United Nations (UN) and many individual countries[1,2] because progress toward such goals can address food insecurity, poverty, natural resource degradation, and environmental damages.[3–5] Policies supporting these goals are not executed in a vacuum. Technological advances, economic growth, demographic transition, food system reorganization, and dietary changes provide a dynamic, intertwined context for policy implementation. Projecting how global food waste amounts and patterns will evolve, and how different policies could alter waste in the face of continued economic development, technical advancement, and dietary evolution will require consistent tracking of food waste over time. However, quality primary data is generally lacking,[6–8] particularly for rapidly growing BRIC countries (Brazil, Russia, India, China),[9] requiring analysts to make the most of existing (often secondary) data to forecast global food waste patterns and trends.

The primary source of waste along the food value chain differs by country. In developing countries waste is greatest at the farm and early stages of the value chain, while in developed countries it is greatest for consumers and consumer-facing segments.[9,10] However, the conclusions drawn in this literature come from comparing countries at different levels of economic development during a narrow range of years[11] rather than tracking food waste within a single country over time through different stages of economic development.

Where repeat observations exist, they typically result from national-level mass balance calculations where food waste is estimated by subtracting projected national caloric needs from national caloric availability (food production plus net imports). For example, USDA's Loss-Adjusted Food Availability data provides annual waste estimates for more than 200 commodities dating to 1970.[12] While useful for drawing broad insights about national food waste, such estimates are subject to potential compounding of errors if each component of the calculation contains measurement errors of its own. Further, annual variation in such measures is often driven by differences in annual food production and population growth, while the assumptions concerning the proportion of food lost and wasted are generally static over time[13] and can lead to infeasible (e.g., negative) country-level estimates of food waste.[14] Hence, such approaches do not provide the dynamic and granular measurement needed for policy evaluation.

In this article, we leverage primary panel data collected from more than 37,000 households enrolled in the China Health and Nutrition Survey (CHNS) from 1991 to 2009 to describe household food waste patterns and trends over a period of dramatic societal, technical, agricultural, and economic changes. The availability of a panel of direct measures of household food waste in this globally-influential country during this period is critical as the extant literature has ascribed households to be a larger driver of waste in more developed economies[10,11] and suggested that household food waste in BRIC countries is increasing.[9] However, no previous household data has tracked waste over a period of such development within a country. The CHNS data documents the types of foods discarded by households from provinces across China, which permits assessment of food waste trends for a broad swath of Chinese society with unprecedented granularity.

Methods

Data are from the CHNS as developed and administered by the Population Center at the University of North Carolina and the National Institute of Nutrition and Food Safety at the Chinese Center for Disease Control and Prevention (CCDCP). Institutional review committees at the University of North Carolina and the CCDCP approved data collection. The survey, developed to study how Chinese economic and social changes affect an array of health and nutrition outcomes, has been used in more than 1,000 peer-reviewed journal articles.[15]

Surveyors interviewed households in Guangxi, Guizhou, Heilongjiang, Henan, Hubei, Hunan, Jiangsu, Liaoning, and Shandong provinces. A multistage, random cluster design was used to draw the sample. Counties within a province were stratified into three income levels, while a weighted sampling scheme yielded four randomly selected counties in each province. Within a county, villages and townships were randomly selected and, then, within each community, 20 households were randomly chosen.[15] The resulting sample is diverse in socioeconomic factors and other related nutritional and demographic measures.

We use the average of daily household food discard measurements over each household's three consecutive day interview period as our measure of household food waste. While numerous definitions of food waste exist,[16] the CHNS definition aligns with the Food and Agriculture Organization's (FAO) definition, which is "...discarding or alternative (non-food) use of safe and nutritious food for human consumption." Notably, uneaten or spoiled food given to animals, which was common among rural Chinese households during this period,[17] is considered food waste by this definition, accentuating FAO's focus on food security.

Behaviors concerning household food acquisition, intake and discard are documented in survey waves from 1991 through 2009 and form the basis for the analysis. The first interview day was randomly chosen across the 7 days of the week to minimize weekly pattern effects. A balance scale (graduation: 10 grams [g] before the year 2004 and a digital scale with graduation 1 g thereafter) was used to weigh food including the amount discarded by households,[18] which included spoiled food or food fed to animals. When weighing was not possible, the weight of discarded food was estimated. The measure of household food consumption uses the food discard measure along with household food inventory and 24-hour diary recall of individual food intake of all household members. Whenever significant discrepancies between the two methods arose, the household and the individuals in question were revisited to reconcile food inventory, intake and discard data. Interviewers were trained nutritionists who received three days of specific training in dietary data collection.

Foods were classified by food type according to the Chinese Food Composition Tables (1981, 1991, and 2002) as developed by the CCDCP (see Table S1 and S2 for food group categorization). In addition, households provided detailed demographic, time use, labor force participation, physical activity, health care, and economic information in each wave. Detailed information on variable construction is available on the CHNS website and in the supplemental materials. While this data represents the most detailed and granular food waste

data of which we are aware, it provides data from only three days in each year, while the act of wasting food can feature intermittent episodes of large discards.[19] This leads to the food waste data featuring considerable variability, e.g., the coefficient of variation for daily per capita grams of food waste across all CHNS data (1.98) considerably exceeds that for daily per capita grams of food acquisition (0.88).

Summary statistics are estimated using Stata (version 16). Many household characteristics explored are correlated (e.g., rural households are typically poorer). To isolate their independent effects, we regress household characteristics on daily per capita waste (grams and Calories). The standard errors, which determine statistical significance of the regression coefficients, are clustered at the household level to accommodate the correlation of error terms that likely occurs due to repeated observation of households over time. We note that regression results do not imply causal relationships. For example, unobserved factors may simultaneously influence waste and explanatory variables (e.g., unobserved ambitiousness of household heads may influence both waste and income) or reverse causality may exist (e.g., high waste prompting refrigerator acquisition). Hence, regression permits additional descriptive insights concerning patterns and trends within a longitudinal data set where other factors are held constant, but should not be interpreted as causal.

Results and Discussion

Summary statistics, including food-related variables, are provided in Table S3 for the entire sample and by decade. Reflecting this dynamic period in China's history, CHNS households experienced notable changes between the decades in average income (98% increase), education (25% fewer household heads reporting no formal education), household size (25% decrease), availability of refrigeration (118% increase), physical activity (21% decrease in heavy physical activity), and dietary composition (24% increase in per capita animal protein intake). Due to the panel nature of the study and the restrictive nature of internal migration from rural to urban areas, the percent of rural versus urban respondents remains relatively constant.

The percent change between averages in 1991 and 2009 are often greater than changes in decadal averages. For example, average CHNS household income increased more than 300% between 1991 (12,694 in 2015 Yuan) and 2009 (41,167 in 2015 Yuan, see Table S4), whereas the decadal increase was 98%. Also, the average household head's age increases from 45.6 in 1991 to 55.7 in 2009, which closely compares to Chinese national trends where median age increased from 24.7 in 1990 to 35.0 in 2010.

Figure 1 presents the food waste trends over the 18 years of the study. Per capita waste declines by more than 20% from an average of nearly 52 g/person/day in the early 1990s to less than 41 g/person/day by 2009 (Figure 1, white bars). These figures extrapolate to 18.8 kg/person/year in 1991 and 14.9 kg/person/year in 2009, which is mid-range of estimates from lesser developed economies, i.e., exceeding estimates from South Africa (7.3 kg/person in 2007) and less than Romanian estimates (32 kg/person in 2006).[11] These figures are less than contemporaneous estimates from the Organization for Economic Cooperation and Development countries during the 2000's, which range from 24 kg/person in the Czech

Republic in 2009 to 212.6 kg/person in Australia in 2006.[11] The decline in food discarded at the household level is even greater (a 49% reduction, see Figure S1 and Table S5 for household level figures) as household size decreased over the study period (from 3.8 household members in 1991 to 2.51 members in 2009).

We note that, in any given wave, only about 60% of households report any food waste during the three interview days (Figure 1, line graph), suggesting that the act of wasting food is not necessarily a daily occurrence among CHNS households. To our knowledge, there does not exist other published data of daily food waste data, which precludes us from assessing the novelty of such a pattern. The lack of trend in the percent of households reporting no waste during the interview days suggests that the secular downward pattern in total grams and Calories of food waste are due to less waste on each waste occasion rather than a decline in the frequency of waste occasions.

When food waste is expressed in calories, the percent decline is greater with a 40% reduction per person (Figure 1, gray bars). Most Calories discarded are carbohydrates, with a slight downtrend with about 70% in the early 1990s and about 63% by 2009 (Figure 2). Total fat and protein Calories discarded also decline though their percentage contribution increases modestly.

The key types of food waste include vegetables and fruits, followed by cereal and then animal proteins (Figure 3), which roughly parallels the corresponding food consumption and acquisition trends and patterns (Figure S2 and S3). In the United States[20] and the United Kingdom,[21] the largest constituent of overall household waste is also in the form of vegetables and fruit while animal proteins are also among the smallest. While similar in the rank ordering of waste categories, the percent of overall waste among CHNS panelists attributable to produce (60–70%) is much higher than comparable U.S. figures (39%).[20] The percent of waste as animal protein is much closer, with 10–14% for CHNS and about 15% in the U.S.[20]

The greatest percent decline in grams discarded between 1991 and 2009 was observed for cereal (46%) followed by fruits and vegetables (13%). The grams of animal protein discarded increased by 13%, which is less than the increase in consumption (53%, Figure S2) and acquisition (48%, Figure S3) over the same period. The types of fruits and vegetables discarded less often over the study period (Figure 4) include leafy vegetables (i.e. Chinese cabbage, green onion) and starchy root vegetables (e.g., potatoes, radishes).

Patterns and Trends by Household Characteristics

We next explore how food waste differs by household characteristics. For example, per capita waste is inversely proportional to household size. Small households (less than three members) discard 81% more per person than households with more than three members in 1991 (Figure 5). Compare these figures to those from the United States where those living alone waste about twice as much as households of 5 or more on a per capita basis.[20] Small households reduce waste the greatest in absolute terms between 2009 and 1991 (45%) and the ratio of waste between the smallest and largest households shrinks such that the smallest households record only 47% more waste per person in 2009 than the largest households.

Waste is lower in 2009 than 1991 for each income groups tracked in Figure S4. The lowest income group (<8,000 2015 Yuan) shows the greatest reduction (36%) compared to the highest income group (>30,000 2015 Yuan, 26% reduction). By 2009 waste for each group is clustered around 38 g/person/day, though the 95% confidence intervals for the groups overlap in most years.

Similar to income groups, each age group observes reductions in waste between 1991 and 2009 (Figure S5), with the 2009 levels appearing in a tight range and the 95% confidence intervals overlapping in most years. The youngest age group (less than 40 years) features the greatest reduction over the study period (39%). Food waste levels and trends reveal little systematic difference by education level (figure omitted), which is consistent with recent findings in the United States.[20] Male-headed households had more waste than female-headed households in the 1990's but similar levels by 2009 (figure omitted). Waste from male-headed households consistently declined between 1997 and 2009 while waste from female-headed households featured both wave-over-wave increases and decreases after 1997.

Several other household characteristics with possible implications for food waste also changed dramatically over this time period. Refrigeration provides a means for extending shelf life, and the percent of CHNS households with refrigeration increased from 16.7% in 1991 to 64.1% in 2009. Households with refrigerators generally discarded less food than households without refrigerators, and both groups featured reductions between 1991 and 2009 (Figure S6). However, the wave-over-wave trend among households with refrigerators also featured several spikes in discard while the downward trend among households without refrigeration was steadier. To our knowledge, there is no previous work assessing food waste by home refrigeration availability.

The frequency of household members eating meals away from home also increased over the study period with only 19.9% of households reporting any such activity during the 3-day study period in 1991 and 26.5% doing so in 2009. Meals away from home may also feature food that is uneaten and discarded, both at the point of preparation and consumption, but these amounts will not appear in CHNS measurements. Households who consumed all meals at home reported more food waste in every wave, though the groups' confidence intervals overlap in every wave except 2000 and 2006 (Figure S7). While results from the United States find little systematic relationship between meals away from home and food waste,[20] eating meals away from home is a much less frequent event among CHNS participants than U.S. consumers. Both groups featured a reduction in discard between 1991 and 2009, though households who ate all meals at home featured a steeper and steadier decline while households who ate at least one meal away from home featured several wave-over-wave increases.

Household heads became more sedentary with 52.6% reporting heavy physical activity in 1991 and only 35.0% doing so in 2009. Physical activity increases the energy needed to maintain body weight and may result in greater food purchases and inventories that provide the necessary antecedent for food waste. Households with heads engaged in heavy physical activity discarded more each wave than other households with confidence intervals only

overlapping in the 1997 wave (Figure S8). Both groups reported similar decreases between 1991 and 2009 (about 12 grams). To our knowledge, no other work explores the relationship between physical activity and food waste.

Patterns and Trends by Geography

We also explore food waste by geographic designation. Waste in rural areas in 1991 was 49% greater than in urban areas, but by 2009 rural waste was only about 22% greater (Figure S9). Previous work in European countries finds no differentiation between rural and urban household food waste[22] while in Lebanon self-reported waste levels in rural households was lower than that of urban households.[23] While rural areas observed steady wave over wave declines and a nearly 25% total decline between 1991 and 2009, urban areas average declined less than 8% during this study period and featured both wave over wave increases and decreases. Rural households tended to be larger, poorer, headed by older individuals, and observe greater reductions in physical activity levels than urban households.

Waste also varied by province (Figure 6) with lighter colors denoting less waste as averaged across all waves and with embedded bar charts denoting relative discard by food type. Hubei features twice as much food discard as the northern Heilongjiang province or the upland Guizhou province. Vegetables and fruits are the predominant waste type except in Guangxi, a tropical-weather province, where grain and cereal waste is greatest. To our knowledge, there is no previous analysis of differences in food waste across different regions in China, though differences in per capita waste across three U.S. cities have been documented be as much as 52%.[20]

Regression Results

In Table 1 we report results for the entire period in columns 1 and 2, for the first 3 waves (1991, 1993. 1997) in columns 3 and 4, and for the last 4 waves (2000, 2004, 2006, 2009) in the final columns. The results reveal that many patterns and trends identified in the previous section persist once other potentially correlated factors are controlled via multiple regression.

Household size and province have the strongest relationship with waste. Households with more than three members are associated with about 18 grams and 26 Calories less waste per person than households with fewer than three members over the entire study (columns 1 and 2). Three-person households are also associated with significantly less waste than the smallest households, though the magnitude is smaller. The effect sizes are smaller in the 2000s than in the 1990s, mirroring the trends observed in Figure 5. This corresponds to findings from developed countries that also find greater per capita waste among smaller households.[22]

Provinces also yield some of the largest regression coefficients. Heilongjiang and Guizhou register the least waste in terms of grams and Calories over the entire period, though Heilongjiang's effects are largely in 2000s while Guizhou's effects are mainly during the 1990s. Hubei, Jiangsu and Guangxi have the largest effects. This points to persistent geographical variation (Figure 6), even when controlling via regression for other systematic differences across provinces such as income and food consumption and storage practices.

This highlights the importance of including a range of locations in any study of food waste in China and in understanding the specific location when interpreting results from single-site food waste studies in China and elsewhere. We also estimate separate regressions for four regions in the data (Table S19) and find differences across regions. For example, income is positively correlated to waste in all regions except the most affluent eastern region, where the most waste is associated with households in lowest income bracket. Such results motivate future research to understand how location-specific factors (e.g., weather, culture, economics) drive persistent geographic variability.

A household's tendency to acquire higher proportions of carbohydrates and fat in their diets is significantly associated with higher levels of waste as well, though the magnitude and significance of the association fades in the 2000s. While previous studies highlight the types of foods that are wasted at the highest rates,[20,21] to our knowledge no previous work ties waste amounts to the composition of food acquired.

The urban versus rural status of the household is among the next largest effects with urban households associated with about 11 fewer grams and 20 fewer Calories of waste with the effect size diminishing in the 2000s. The next strongest relationship is with the physical activity of the household head. Lower physical activity is associated with about 9 fewer grams and about 24 fewer Calories of food waste than heavy activity with similar effect sizes in each decade.

There is little relationship between food waste and income when the entire study period is considered and geography is controlled via province-level dummy variables. However, in the 1990s there tends to be a negative association between middle income and waste measured in Calories. In the 2000s a more standard (and statistically significant) positive relationship consistent with some previous literature[24,25] is observed. Greater waste both in terms of mass and energy is associated with higher income categories in the 2000s.

Availability of home refrigeration is negatively correlated with food waste as measured in Calories (about 7 fewer Calories discarded per day than those without a refrigerator), though the magnitude of the effect was smaller in the 2000s than in the 1990s. While previous research has examined how food waste is related to refrigerator utilization in developed contexts,[26,27] to our knowledge, we are the first to investigate differential waste rates between households with and without home refrigeration. The availability of home refrigeration among CHNS households expanded from 17% in 1991 to 64% in 2009. Given non-universal home refrigeration in China, India and other growing economies,[28] understanding the effect of refrigerator availability on food waste will be crucial for understanding the net effect of these energy-intensive appliances on greenhouse gas emissions and overall environmental impacts.

Dining at a restaurant at least once during the three-day interview period is positively correlated with waste in grams (about 5 more grams than those who never reported eating at a restaurant during the interview period) with the magnitude and statistical significance of the results greater in the 2000s. This aligns with the literature which finds a positive

correlation between eating meals away from home and household food waste both in developing[23] and developed country contexts.[19,25,29,30]

In terms of education, households where the head was in the most educated category (more than lower middle school) are associated with significantly more waste than households with a head with no education, though the result is only statistically significant when food waste is measured in Calories (about 10 Calories more) and when measured over the entire study period. This is qualitatively similar to findings in the Czech Republic[24] though others find no significant correlation,[31] while still others find household waste lower when formal education levels are higher.[23]

The age of the household head has little association with food waste generated. However, holding constant the total number of household members, having one additional member younger than 18 is associated with 4 fewer grams and about 6 fewer Calories of waste. This effect was strongest in the 1990s and became smaller and statistically insignificant in the 2000s.

Gender is also associated with waste. Households populated with more adult female members (rather than male adult members) are associated with about 5 grams and 7 Calories less waste over the entire study, where these effects are slightly larger in the 2000s compared to the 1990s. The association between waste and the gender of the household head switches signs between decades: positive in the 1990s and negative in the 2000s. The later negative correlation aligns with some results in the literature.[22,31]

The final set of effects involve the study year. Controlling for numerous characteristics of the household and its members, the effect of later study years is negative and significant starting in 2004 (versus the omitted year of 1991). Compared to 1991 the per person grams of food waste associated with households in 2006 and 2009 is about 39% lower (20/51.7, where 51.7 is the average g/person/day wasted in 1991) while the Calories per person are lower by about 58% (41.2/70.9 where 70.9 is the average in 1991) and 48% (34.3/70.9).

Conclusions

The amount of food wasted in Chinese households declined significantly between 1991 and 2009 despite rapid increases in China’s national income and economic development status factors which the literature has previously associated with greater levels of household and consumer food waste across countries.[9–11] We find a 20% decline in per capita food waste among CHNS households during a period in which average CHNS household incomes increased by more than 300%, which counters dominant narratives in the literature that post-consumer waste has been increasing over the past few decades including in China and other BRIC countries and that food waste increases as incomes increase.[9,11]

To put the magnitude of these reductions into perspective, recall that the United Nations and several individual countries have stated goals to reduce avoidable food waste across their respective food systems by 50% by 2030 relative to 2015 baselines. This sample of Chinese households reduced food waste within the boundaries of their homes by 49% over the 18 year study period (179.6 vs. 94.3 g/household/day, see Figure S1) while on a per person

basis, a 20% reduction was observed (Figure 1). Turning to the regression results we observe that the grams of food waste per person in 2009 was associated with about a 39% reduction versus 1991 even when holding constant other potentially confounding factors of the household and its location, suggesting that factors not included in the regression (e.g., changing food purchasing and handling habits) may be important for understanding trends in household food waste.

Such reductions occurred over the nearly two decades of the study in the absence of any formal or explicit food waste reduction goals or strategies at the country, province or city levels. While such results will vary by country, and emphasizing our results are correlative and not causal, our results suggest food waste levels have the potential to change in response to observable societal factors such as income, rural/urban migration, food consumption habits, food storage technologies, household composition, and physical activity levels, and in response to factors not controlled in our analysis, such as changing food acquisition and preparation habits, market liberalization, and societal norms concerning food.

While we document substantial reductions in food waste within the households in the CHNS, we emphasize that households represent only one possible source of consumer-level food waste. Food waste can be generated in other consumer-facing institutions, such as in restaurants and other food services outlets that CHNS households began to frequent more often throughout the study period. The literature suggests that China differs from western countries because the fraction of consumer-level food waste from catering and restaurant settings is greater than that created in household settings.[32] For example, average per meal food waste in school cafeterias in Beijing range from 74 g/meal in university canteens[33] to 130 g/meal in middle and high schools[34] to an average of 93 g/person/meal of plate waste from restaurants in four Chinese cities in 2015.[35] These estimates of per meal per person food waste are two to three times greater than the per person food waste measured in CHNS households in 2009 for an entire day, a pattern which is also identified in the United States.[36] Hence, not only will it be important to understand the patterns and trends in food waste generated within households across China, but also to understand the trends and patterns of food waste generated from meals eaten away from home. This will require more robust and representative measures of waste in restaurants, canteens and other food service outlets in urban and rural areas of China from a diversity of regions, and improved tracking of trends within these institutions.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

- We analyze food waste measured by 37,000+ Chinese households from 1991 to 2009
- Food waste per person declined by about 20% (grams) and by about 40% (Calories)
- Incomes among study households more than tripled during the study period
- Food waste reduction was greatest among small households and rural households
- Higher waste if rural residence, intense physical activity, no home refrigeration

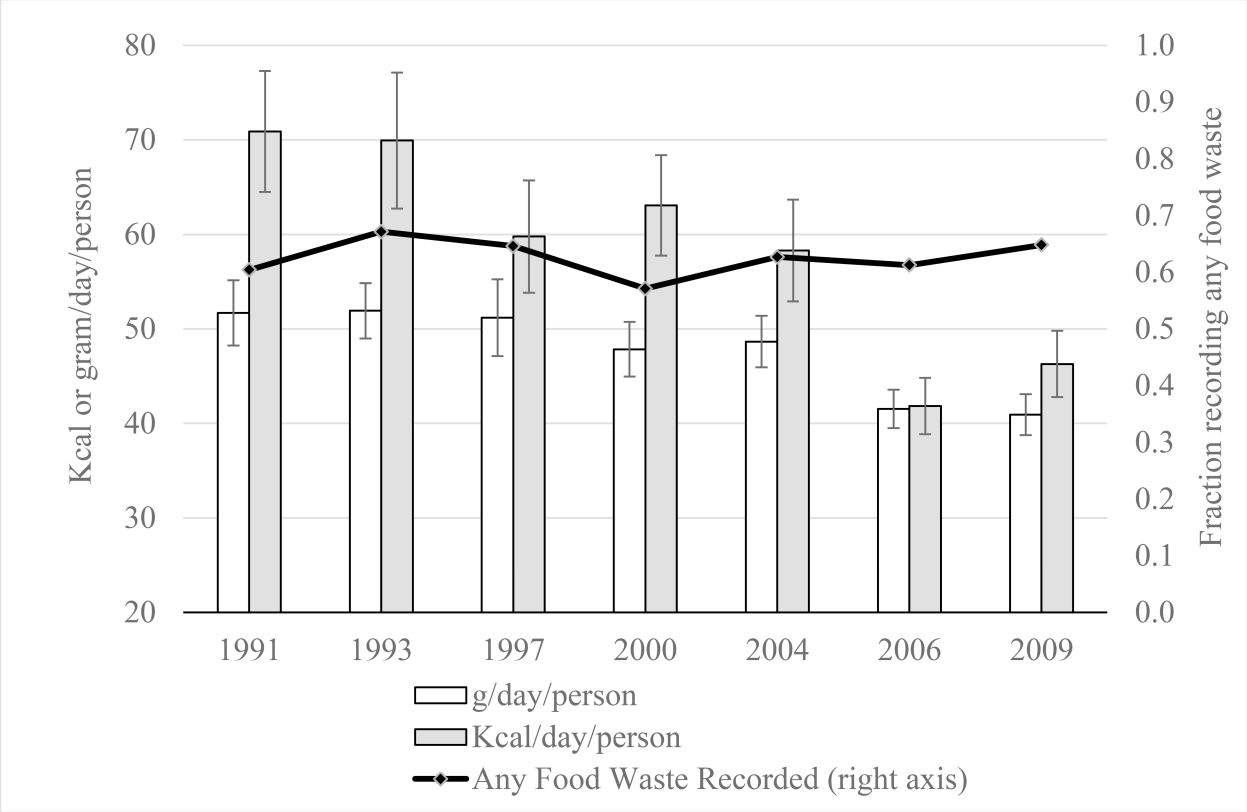

Figure 1.

Food waste by survey wave. Notes: 95% confidence intervals presented on bar figures. Black line depicts the fraction of households reporting any waste during the three-day interview period and maps to the right vertical axis scale. See Table S6 for data.

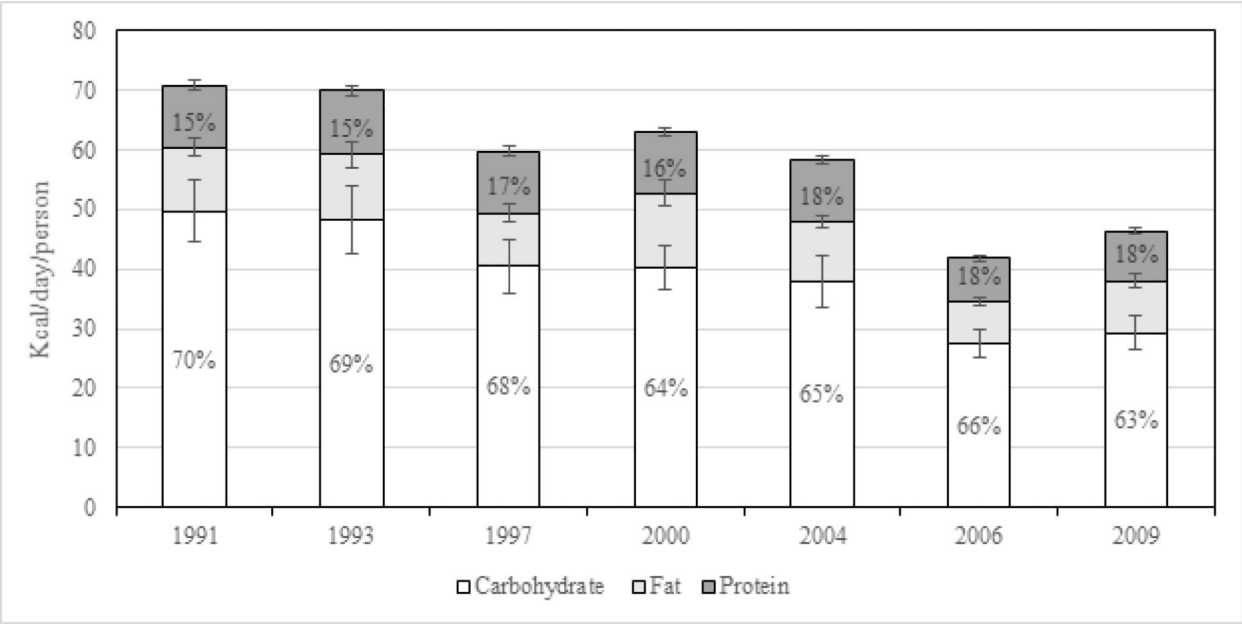

Figure 2.

Food Waste by Macronutrient and Wave. Notes: 95% confidence intervals presented at the top of each stacked bar element. Percentage figures within bar segments represent the percent of annual waste attributable to the macronutrient represented by that bar segment. See Table S6 for data.

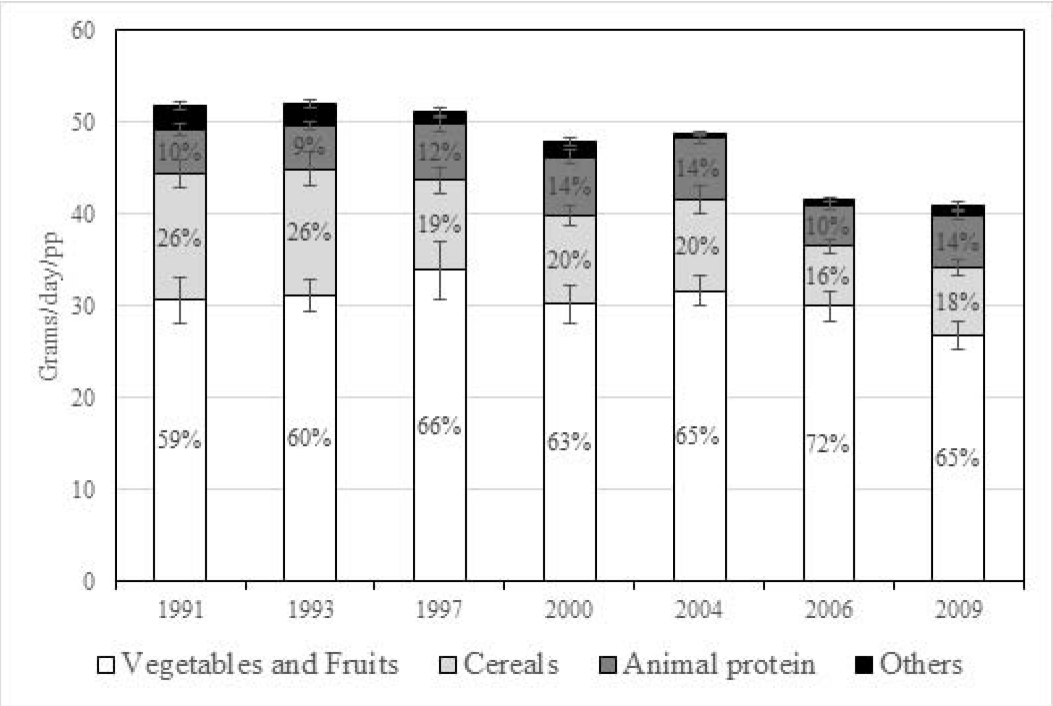

Figure 3.

Food Waste by Food Type. Notes: 95% confidence intervals presented at the top of each stacked bar element. Percentage figures within bar segments represent the percent of annual waste attributable to the food type represented by that bar segment. See Table S7 for data.

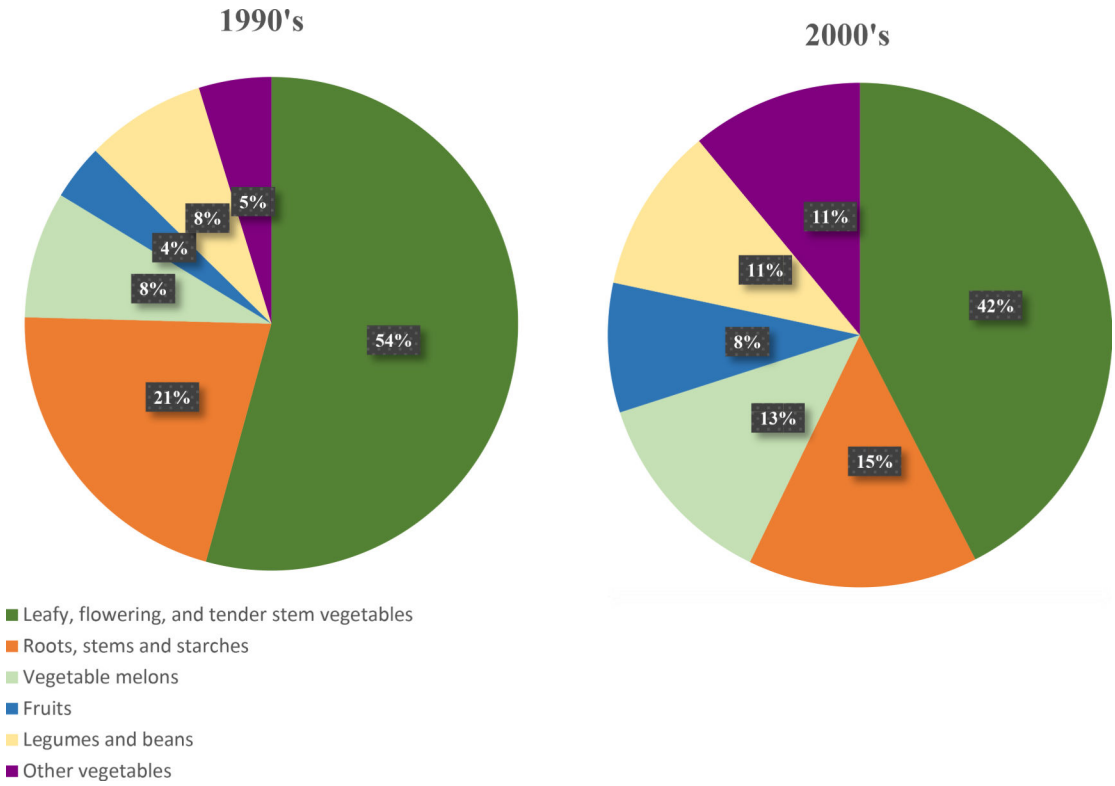

Figure 4.
Fruit and Vegetable Waste: Percent of Mass by Food Type and Decade. Notes: See Table S10 for data.

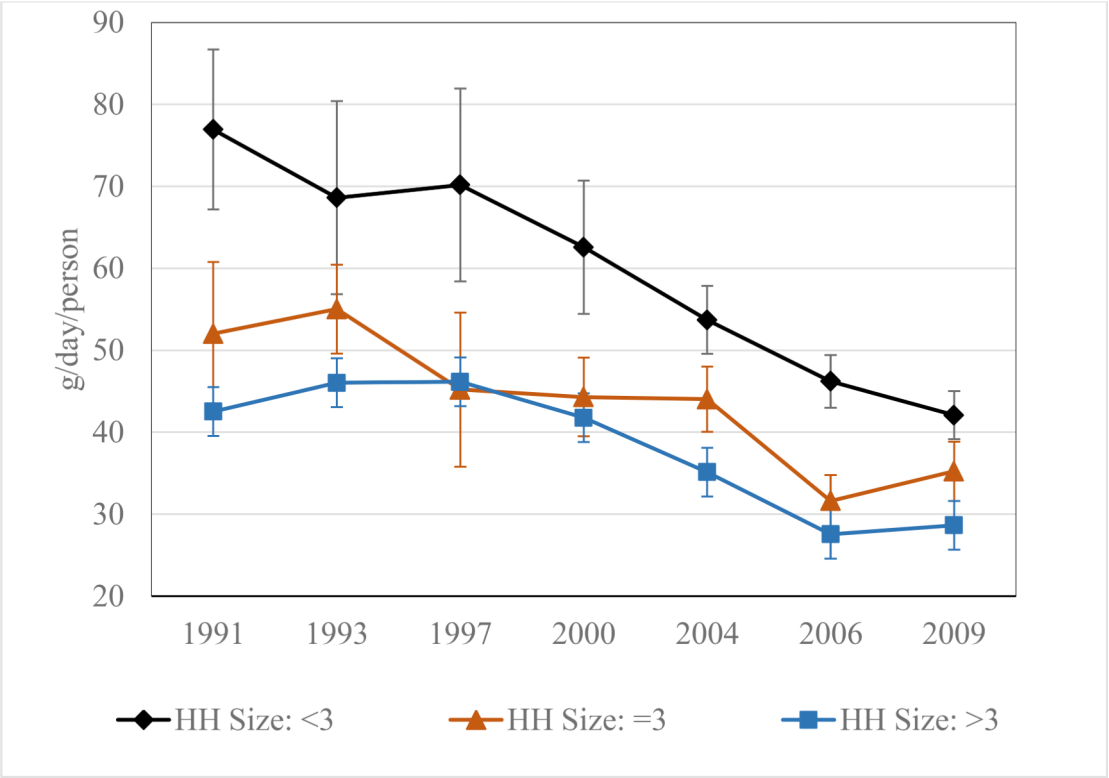

Figure 5.
Food Waste by Household Size by Wave. Note: 95% confidence intervals presented. See Table S11 for data.

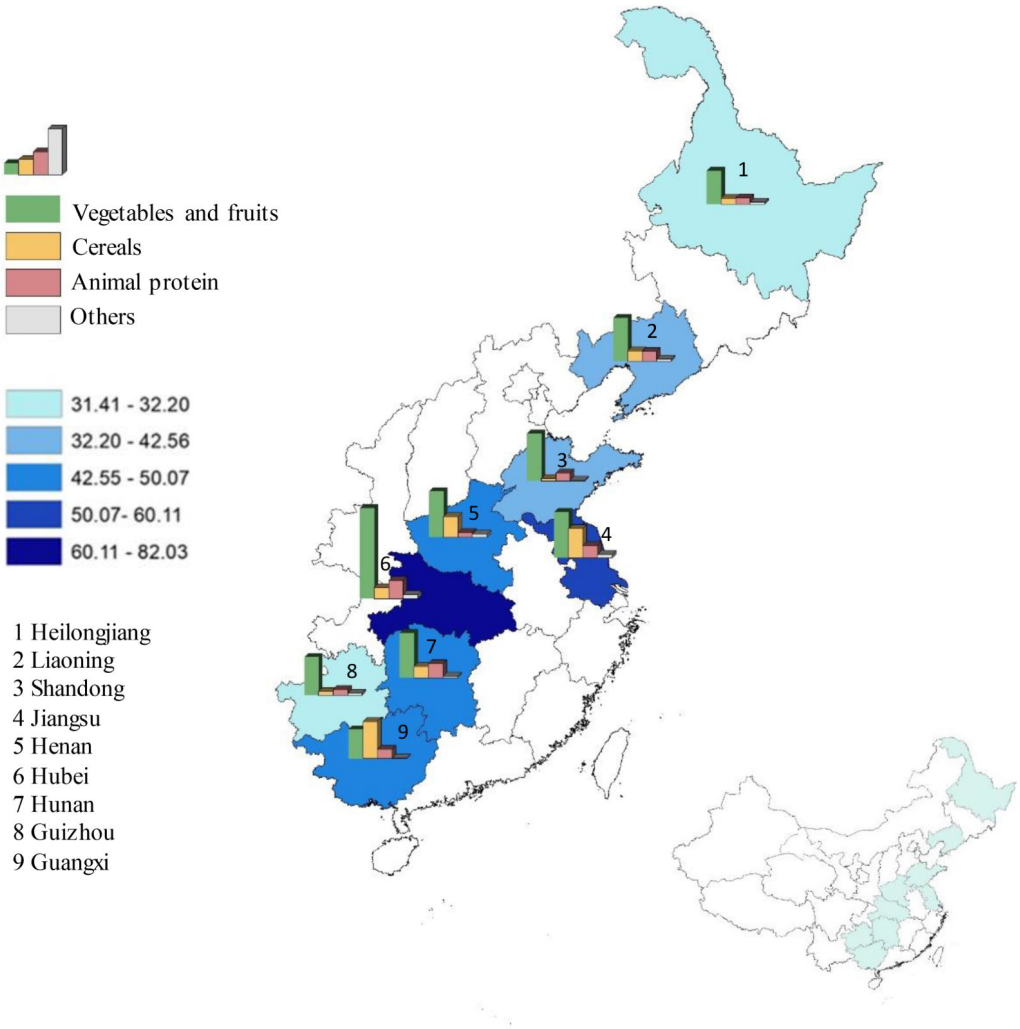

Figure 6.

Food Waste by Food Type and Province: Average 1991–2009 Waves. Note: color depicts province average daily waste in grams while the bar chart embedded in each province relays relative waste by food type within the province. See Table S18 for data.

Table 1.

Regression Results for Average Food Waste Per Person Per Day

	(1)	(2)	(3)	(4)	(5)	(6)
	1991–2009		1990s		2000s	
VARIABLES	**OLS grams**	**OLS Kcal**	**OLS grams**	**OLS Kcal**	**OLS grams**	**OLS Kcal**
Panel A: Food related behaviors						
Carbohydrates: % of food acquisition	13.370*	58.215**	22.247*	93.810**	8.872	31.518*
	(5.939)	(11.145)	(10.027)	(19.021)	(7.450)	(13.201)
Fat: % of food acquisition	1.284	44.683**	8.917	77.686**	−1.810	24.434
	(6.775)	(13.459)	(12.675)	(25.134)	(7.226)	(13.996)
Panel B: Household Characteristics						
Urban (yes=1)	−10.578**	−19.504**	−13.822**	−25.795**	−7.963**	−14.665**
	(1.520)	(2.415)	(2.321)	(3.965)	(1.874)	(2.815)
Household Size: (Base: HH Size: <3)	*Joint*	*Joint*	*Joint*	*Joint*	*Joint*	*Joint*
	*p=0.000***	*p=0.000***	*p=0.000***	*p=0.000***	*p=0.000***	*p=0.000***
=3	−11.988**	−20.161**	−21.574**	−40.650**	−9.541**	−11.840**
	(2.158)	(3.397)	(6.161)	(10.195)	(1.826)	(3.292)
>3	−18.274**	−25.541**	−25.601**	−38.629**	−14.774**	−18.593**
	(2.416)	(4.478)	(5.369)	(10.139)	(2.726)	(4.881)
# of Adult Female	−5.246**	−7.374**	−4.590*	−4.609	−5.705**	−9.244**
	(1.236)	(2.530)	(1.857)	(3.930)	(1571)	(2.992)
# of members younger than 18	−4.055**	−5.504*	−4.264**	−7.053*	−1.667	−2.502
	(1119)	(2.317)	(1.652)	(3.279)	(1.291)	(2.285)
Household Income (Base: HH Income: <8K)	*Joint*	*Joint*	*Joint*	*Joint*	*Joint*	*Joint*
	*p=0.049**	*p=0.104*	*p=0.539*	*p=0.192*	*p=0.000***	*p=0.002***
8–15K	−0.503	−6.432*	−3.805	−13.938**	4.088*	3.755
	(1.897)	(3.876)	(2.962)	(6.623)	(2.338)	(3.681)
15–30K	3.022	−2.195	−2.311	−15.092*	8.285**	11.296**
	(2.091)	(4.002)	(3.725)	(7.471)	(2.365)	(3.840)
>30K	3.815	0.220	−0.502	−16.351	9.438**	13.325**
	(2.147)	(4.162)	(5.148)	(9.340)	(2.275)	(3.850)
Own Fridge (yes=1)	−2.402	−6.615**	−1.999	−10.157*	−2.899	−6.949*
	(1.584)	(2.504)	(3.025)	(4.127)	(1.800)	(3.086)
Ever eat at restaurants (yes=1)	4.730**	0.905	1.841	−3.419	6.866**	5.139
Panel C: HH head characteristics	(1514)	(2.312)	(2.876)	(4.329)	(1.613)	(2.738)
Male (yes=1)	−1.614	−2.774	5.479*	7.709	−6.483*	−9.570*
	(1.903)	(3.272)	(2.477)	(4.351)	(2.594)	(4.272)
Household head age (Base: <40)	*Joint*	*Joint*	*Joint*	*Joint*	*Joint*	*Joint*
	p=0.154	*p=0.192*	*p=0.151*	*p=0.343*	*p=0.654*	*p=0.801*

	(1)	(2)	(3)	(4)	(5)	(6)
	1991–2009		1990s		2000s	
VARIABLES	**OLS grams**	**OLS Kcal**	**OLS grams**	**OLS Kcal**	**OLS grams**	**OLS Kcal**
40–50 years	−3.451	−8.165*	−3.743	−10.799	−1.572	−3.080
	(1.954)	(3.914)	(3.186)	(6.415)	(2.174)	(3.681)
50–60 years	−4.547	−9.254	−4.336	−12.950	−2.442	−2.740
	(2.472)	(4.784)	(4.439)	(8.506)	(2.419)	(3.941)
>60 years	−2.070	−8.701	4.582	−11.466	−3.226	−4.140
	(3.532)	(6.157)	(7.977)	(13.184)	(2.587)	(4.545)
Household head education (Base: None)	*Joint*	*Joint*	*Joint*	*Joint*	*Joint*	*Joint*
	p=0.287	*p=0.088*	*p=0.492*	*p=0.500*	*p=0.453*	*p=0.121*
Primary School	2.357	4.732	4.327	6.181	1.955	4.523
	(2.042)	(3.917)	(3.479)	(6.600)	(2.191)	(4.193)
Lower Middle School	1.688	2.186	4.863	7.516	−0.005	−1.153
	(2.385)	(4.730)	(4.458)	(9.750)	(2.343)	(4.027)
More than Lower Middle School	5.013	9.850*	9.273	13.484	2.883	6.119
	(2.933)	(4.924)	(6.266)	(9.229)	(2.774)	(4.966)
Physical activity: (Non-heavy=1)	−8.763**	−23.813**	−8.631**	−27.140**	−9.054**	−19.528**
	(1.801)	(3.330)	(3.018)	(5.732)	(2.142)	(3.784)
Province (Base: Liaoning)	*Joint*	*Joint*	*Joint*	*Joint*	*Joint*	*Joint*
	*p=0.000***	*p=0.000***	*p=0.000***	*p=0.000***	*p=0.000***	*p=0.000***
Heilongjiang	−11.246**	−21.887**	−3.726	−26.739	−12.577**	−15.817**
	(3.583)	(4.832)	(16.823)	(21.895)	(2.646)	(3.141)
Jiangsu	15.892**	47.074**	32.261**	41.905**	2.920	40.408**
	(3.426)	(7.367)	(6.195)	(14.872)	(3.217)	(6.903)
Shandong	−0.650	−20.803**	−1.216	−55.036**	−1.440	−6.720*
	(2.404)	(3.727)	(4.237)	(10.333)	(2.814)	(3.300)
Henan	6.397*	12.336*	2.633	−10.483	7.108	18.685**
	(3.209)	(6.118)	(5.315)	(13.709)	(3.868)	(6.090)
Hubei	37.462**	17.543**	24.438**	−34.197**	46.575**	46.883**
	(2.821)	(4.248)	(4.001)	(10.613)	(3.998)	(4.605)
Hunan	5.561*	6.735	−6.458	−33.321**	12.758**	24.901**
	(2.375)	(4.190)	(3.801)	(10.894)	(2.985)	(4.082)
Guangxi	12.360**	59.072**	13.710*	48.745**	8.368**	52.740**
	(2.953)	(5.791)	(5.898)	(13.498)	(2.707)	(5.103)
Guizhou	−8.071**	−25.754**	−17.616**	−66.504**	−2.865	−7.263*
	(2.162)	(3.969)	(3.998)	(11.018)	(2.611)	(3.449)
Survey year	*Joint*	*Joint*	*Joint*	*Joint*	*Joint*	*Joint*
	*p=0.000***	*p=0.000***	*p=0.958*	*p=0.658*	*p=0.000***	*p=0.000***
	(Base: 1991)	(Base: 1991)	(Base: 1991)	(Base: 1991)	(Base: 2000)	(Base: 2000)

	(1)	(2)	(3)	(4)	(5)	(6)
	1991–2009		1990s		2000s	
VARIABLES	**OLS grams**	**OLS Kcal**	**OLS grams**	**OLS Kcal**	**OLS grams**	**OLS Kcal**
1993	−0.061	−1.235	0.553	1.323		
	(2.343)	(4.995)	(2.336)	(5.063)		
1997	0.609	−7.338	−0.115	−3.548		
	(2.863)	(4.884)	(2.747)	(4.978)		
2000	−4.862	−8.424				
	(2.693)	(4.624)				
2004	−13.265**	−24.254**			−7.212**	−14.516**
	(2.726)	(4.824)			(2.272)	(3.896)
2006	−20.185**	−40.024**			−13.648**	−29.488**
	(2.792)	(4.825)			(2.205)	(3.684)
2009	−20.152**	−32.778**			−13.702**	−23.036**
	(3.025)	(5.067)			(2.434)	(4.057)
Constant	70.215**	84.432**	69.364**	99.612**	63.025**	67.114**
	(6.375)	(13.200)	(10.650)	(25.719)	(7.084)	(12.348)
Observations	22,039	22,039	8,479	8,479	13,560	13,560
R-squared	0.041	0.050	0.040	0.062	0.057	0.049
Cluster at HH	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses

** p<0.01

* p<0.05