Excessive Food Consumption in Irish Adults: Implications for Climatic Sustainability and Public Health.

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Abstract

Introduction: Food consumption accounts for 20-30% of greenhouse gas emissions in the EU. Certain foods have higher emissions than others and are often the target of policy makers to reduce greenhouse gasses associated with food consumption. However, food policy should aim to address both climatic and health imbalances concurrently and hence have more significant impact. Targeting excessive food consumption as a mitigation strategy for greenhouse gas emissions may also have a concurrent impact on the global obesity epidemic

Objective: To evaluate the greenhouse gas emissions (GHGE) associated with the excessive food and energy intake in Irish adults.

Methods: A secondary analysis of nationally representative data from the National Adult Food & Nutrition Survey, 2011, was conducted. The demographic characteristics, food consumption patterns and diet-associated GHGEs were compared across categories of increasing levels of relative energy intake. One-way ANOVA ($p<0.05$) was used to determine the level of significance across quintiles of relative energy intake.

Results: Different dietary patterns were evident between the categories of varying relative energy intake. A strong positive correlation ($r = 0.736; p< 0.001$) was evident between dietary GHGE and the EI relative to one’s requirements. In Irish diets, animal products contributed to a large proportion of total dietary GHGE but accounted for much less of overall EI. Plant-based foods were the lowest contributors to total GHGE. When constructing strategies to mitigate dietary carbon emissions, it is important to carefully consider all aspects of sustainability. The exclusion of certain food groups from the average diet may provoke health, economical and/or cultural repercussions. An adherence to the Irish dietary guidelines, including a decrease of EI, can viably attenuate dietary environmental impact

Conclusions: The results offer further evidence to support the hypothesis that excessive energy consumption and the overconsumption of certain food types are detrimental to overall diet-associated carbon emissions levels, and that adhering to the current Irish dietary guidelines can potentially lower dietary related GHGE.

Introduction

The Food and Agriculture Organisation (FAO) of the United Nations have estimated that approximately one-third of global greenhouse gas emissions (GHGE) can be attributed to agriculture and deforestation (FAO, 2015). In the European Union, food consumption has been estimated to be responsible for 20-30% of the environmental impacts of total household greenhouse gas emissions (EC, 2006). Hence, the issue of sustainable diets and the impact of food consumption on climate change have received increased attention in recent years.

National dietary recommendations and guidelines are a potentially important policy tool for reducing the environmental impacts associated with the food system. Food-based dietary guidelines are developed to give a general indication of what a population should be eating and to address public health concerns, such as cardiovascular disease and obesity (Montagnese *et al.* 2015). To date, Irish national dietary recommendations have overlooked the environmental consequences of food consumption. However, Sweden, The Netherlands, Australia and the United Kingdom have incorporated some elements of environmental sustainability into their dietary guidelines. The latest Swedish food-based guidelines repeatedly emphasise the importance of making food choices that have beneficial impacts on both human health and the environment. The report on the dietary guidelines advises the population that a plant-based diet has a lower environmental impact compared to a diet consisting of large quantities of red and processed meats (Swedish National Food Agency, 2015).

A longstanding feature of food-related public health guidelines has been excessive energy intake. The health consequences of constant overconsumption of food have been well documented in recent years whereby the rapid increase in the obesity epidemic has been attributed to excess energy intake (Uauy and Díaz, 2005). However, in most countries this has been overlooked as a strategy to concurrently reduce the climatic impact of excessive consumption. A French study, conducted by Vieux *et al.* (2012), explored the effects of reducing energy intake on diet-associated carbon emissions. The results suggested that when the energy intakes of the population were matched to meet the respective individual energy needs, the diet-associated GHGE was seen to decrease by either 10.7% (low physical activity assumed) or 2.4% (moderate activity level assumed). Hence by extrapolation, reducing total caloric intake to meet energy needs leads to a decrease in GHGE (Vieux *et al.* 2012). Another French study illustrated that diets defined as “low-carbon” and “more sustainable” both provided lower energy intake, a decrease of 8-10% in the “more sustainable” diet, in addition to lower GHGE and lower daily cost compared to “average diets” (Masset *et al.* 2014). This positive correlation between total energy intake and total GHGE was also observed in a representative Australian study (Hendrie *et al.* 2016). It is therefore clear that the overconsumption of food energy contributes to avoidable environmental impacts, and that public health campaigns targeted at reducing energy intake coincide with healthy eating guidelines, further implying benefits to human health. A study conducted in 2011 doubted that the reduction of energy to meet individual’s needs would significantly reduce diet-associated GHGE (Tucker *et al.* 2011). The researchers claimed that since overconsumption/obesity involves relatively small, consistent excess energy intakes, the reduction of energy consumption would have limited environmental benefits.

In addition to promoting a healthier lifestyle and prevention of chronic disease, promoting a healthy diet which encourages the reduction in energy consumption to meet requirements may result in the food system becoming less carbon-intensive. Therefore the aim of this study was to determine if guidelines to reduce energy intake relative to energy requirements would result in a reduction in associated GHGEs, using nationally representative food consumption data for Irish adults.

Methodology

National Adult Nutrition Survey (NANS) and GHGE

The National Adult Nutrition Survey (NANS) collected data on habitual food and beverage from a representative sample of 1,500 Irish adults (IUNA, 2011). In summary, food and beverage intake was measured using a semi-weighed food diary over four consecutive days with weekends and weekdays equally represented. Weight and height were measured using standard procedures and used to calculate body mass index (BMI; kg m^{-2}). Estimated energy requirement was calculated accounting for an individual's age, sex, weight, height, and physical activity level.

Extensive detail on the methodology used to derive GHGE and the aggregation of food groups has been previously published by Hyland *et al.* (2017a). All foods consumed were assigned to one of 67 food groups. Emission factors were identified from the literature and assigned to each of the 67 food groups to calculate GHGE. Emission factors included emissions associated with food production, packing, distribution, storage/refrigeration, transportation, food handling/preparation, and consumer waste. The 67 food groups were further aggregated into 16 food groups of similar characteristics. For instance, 'red meat' comprised of 'beef and veal', 'lamb', 'burgers', 'offal and offal dishes'. Whereas, 'processed meat' includes 'sausages', 'meat products' and 'meat pies and pastries'.

Data and Statistical Analysis

Statistical analyses were carried out using IBM SPSS Statistics version 24.0 (IBM Corp. Released 2016. IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp.). Of the total sample, 493 respondents were classified as energy misreporters and were excluded from data analyses. Following the exclusion of misreporters, the population was divided into quintiles based on EI:EER, with the first quintile containing those with the lowest EI relative to their EER, to the fifth quintile consisting of subjects with the highest EI relative to their EER. Mean daily intakes of macronutrients, food groups and associated GHGEs were compared across quintiles. Significant differences were identified using ANOVA.

Results

Table 1 presents the demographic and dietary characteristics across increasing quintiles of EI:EER for men and women. In men, significant differences were observed for BMI, which decreased with increasing quintile. EI, % energy from fat and GHGEs also increased significantly with increasing quintile. There was no significant difference in percent energy from CHO, while protein intake decreased significantly with increasing quintile. Only significant increases in energy intake and GHGEs across increasing quintiles were observed in women. No differences were observed for macronutrients or BMI.

Table 1 Demographic and dietary characteristics across increasing quintiles of EI:EER for men and women

	Quintiles of EI:EER																		
	Q1: Lowest Consumers			Q2: Low Consumers			Q3: Moderate Consumers			Q4: High Consumers			Q5: Highest Consumers			Total			
	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Sig.
Male			67			79			83			83			91			403	
Age	45	16	67	41	16	79	42	17	83	45	18	83	43	20	91	43	18	403	0.668
BMI	28	4	65	27	4	76	26	4	82	27	4	79	25	3	85	27	4	387	0.004 **
Energy Intake (kcal)	2322	452	67	2465	402	79	2527	415	83	2755	427	83	3154	468	91	2669	523	403	0.000 ***
% fat energy	32.8	5.8	67	33.9	5.7	79	35.0	5.3	83	34.4	6.8	83	36.1	7.3	91	34.6	6.3	403	0.017 *
% protein energy	16.8	2.9	53	16.5	2.9	73	16.5	3.2	79	15.8	3.0	76	15.5	2.9	82	16.2	3.0	363	0.040 *
% carbohydrate energy	44.0	9.0	53	44.7	7.0	73	45.0	7.5	79	45.4	7.8	76	45.1	8.8	82	44.9	8.0	363	0.909
Hrs per day watching television	2.9	1.6	61	2.6	1.5	72	3.2	1.6	71	3.0	1.4	72	2.5	1.3	79	2.8	1.5	355	0.088
Total GHGE (g CO_2 eq)	7447	2206	67	7721	2021	79	7325	2173	83	8202	2140	83	9140	2620	91	8014	2343	403	0.000 ***
Emissions Intensity (g of CO_2 per kcal)	3.2	0.7	67	3.1	0.7	79	2.9	0.7	83	3.0	0.7	83	2.9	0.7	91	3.0	0.7	403	0.009 **
Female			91			84			78			78			69			400	
Age	44	15	91	46	17	84	46	16	78	46	17	78	51	18	69	47	17	400	0.096
BMI	27	4	91	26	5	82	26	5	73	26	4	76	26	5	67	26	5	389	0.623
Energy Intake (kcal)	1698	267	91	1766	274	84	1958	321	78	2059	332	78	2260	376	69	1930	370	400	0.000 ***
% fat energy	35.1	5.7	91	35.6	5.6	84	36.0	5.9	78	36.1	5.6	78	35.2	4.9	69	35.6	5.6	400	0.744
% protein energy	16.4	2.8	79	16.1	3.3	75	16.3	3.4	69	15.8	3.2	74	15.7	2.7	63	16.1	3.1	360	0.578
% carbohydrate energy	46.8	6.2	79	46.3	6.7	75	46.6	6.2	69	45.2	7.0	74	46.8	5.9	63	46.3	6.4	360	0.498
Hrs per day watching television	2.7	1.4	85	2.8	1.4	74	2.6	1.5	71	2.5	1.3	73	2.8	1.5	59	2.7	1.4	362	0.583
Total GHGE (g CO_2 eq)	4765	1270	91	4942	1237	84	5117	1240	78	5703	1378	78	6375	1849	69	5332	1502	400	0.000 ***
Emissions Intensity (g of CO_2 per kcal)	2.8	0.6	91	2.8	0.7	84	2.6	0.6	78	2.8	0.6	78	2.8	0.7	69	2.8	0.6	400	0.342

*. Means are significantly different at the 0.05 level (2-tailed).

**. Means are significantly different at the 0.01 level (2-tailed).

***. Means are significantly different at the 0.001 level (2-tailed).

Mean daily food consumption and the associated GHGEs across increasing quintile of over consumption is presented in Table 2. Across the quintiles of relative EI, there was a significant difference ($p<0.001$) between the mean total food weight consumed per day (grams). A direct relationship is observed between the amount of food consumed and the level of EI relative to participant's needs, with the greatest average total grams of food consumed by the highest quintile. The mean total GHGE for each group replicates the trend of total grams consumed ($p<0.001$); the higher EI relative to requirement, the higher the level of diet-associated carbon emissions.

Table 2 Mean daily food consumption and the associated GHGEs across increasing quintile of over consumption

	Quintiles of EI:EER																		
	Q1: Lowest Consumers			Q2: Low Consumers			Q3: Moderate Consumers			Q4: High Consumers			Q5: Highest Consumers			Total			
Grams of aggregated food consumed per day	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Sig.
Total	2806 [a]	877	158	2997 [ab]	1038	163	2966 [ab]	936	161	3146 [bc]	942	161	3355 [c]	981	160	3054	972	803	0.000 ***
Starchy Foods	353 [a]	124	158	391 [ab]	152	163	388 [ab]	149	161	408 [bc]	139	161	449 [c]	161	160	398	148	803	0.000 ***
Dairy	245 [a]	181	158	248 [ab]	184	163	317 [bc]	236	161	301 [ac]	212	161	364 [c]	224	160	295	213	803	0.000 ***
Vegetables	78	63	158	82	62	163	80	64	161	79	65	161	85	61	160	81	63	803	0.847
Fruit	103	111	158	105	116	163	111	121	161	122	130	161	107	115	160	110	119	803	0.632
Legumes/Pulses/Nuts	27	28	158	30	40	163	28	34	161	30	33	161	33	40	160	29	35	803	0.584
Red Meat	43 [a]	38	158	47 [ab]	45	163	42 [ab]	42	161	51 [ab]	46	161	58 [b]	49	160	48	45	803	0.004 **
Eggs/Poultry/Pork	81	51	158	84	51	163	81	52	161	85	54	161	89	62	160	84	54	803	0.656
Fish	27	32	158	26	33	163	25	34	161	27	38	161	33	47	160	27	37	803	0.374
Processed Meat	29	38	158	27	40	163	36	45	161	32	40	161	40	45	160	33	42	803	0.042 *
Savories	32 [a]	40	158	33 [a]	48	163	45 [ab]	58	161	46 [ac]	61	161	56 [bc]	89	160	43	62	803	0.002 **
High-Sugar Foods	81 [a]	60	158	90 [a]	65	163	97 [a]	60	161	105 [ab]	67	161	128 [b]	92	160	100	71	803	0.000 ***
Fats/Oils	19 [a]	12	158	22 [ab]	15	163	21 [ab]	18	161	26 [bc]	20	161	27 [bc]	22	160	23	18	803	0.000 ***
Carbonated Beverages	93	142	158	94	165	163	82	133	161	132	211	161	134	240	160	107	184	803	0.026 *
Other Beverages	1178	529	158	1287	721	163	1243	680	161	1257	694	161	1222	644	160	1238	657	803	0.648
Alcohol	360	697	158	363	587	163	307	545	161	373	556	161	447	766	160	370	636	803	0.402
Miscellaneous	56	60	158	69	75	163	65	67	161	69	71	161	82	75	160	68	70	803	0.020 *
GHGE emissions associated with aggregated food groups per day (g CO_2 eq / day)	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Sig.
Total	5902 [a]	2177	158	6289 [ab]	2166	163	6256 [ab]	2094	161	6991 [bc]	2198	161	7948 [c]	2690	160	6678	2382	803	0.000 ***
Starchy Foods	586 [a]	190	158	636 [ab]	237	163	643 [ab]	235	161	686 [bc]	218	161	759 [c]	254	160	662	235	803	0.000 ***
Dairy	619 [a]	411	158	632 [a]	424	163	804 [bc]	523	161	775 [ab]	462	161	946 [c]	522	160	755	485	803	0.000 ***
Vegetables	70	68	158	66	62	163	74	91	161	72	92	161	79	79	160	72	79	803	0.656
Fruit	74	78	158	76	83	163	78	85	161	88	95	161	75	76	160	78	84	803	0.513
Legumes/Pulses/Nuts	46	46	158	50	69	163	49	60	161	51	54	161	56	66	160	50	60	803	0.675
Red Meat	1496 [a]	1337	158	1647 [ab]	1572	163	1449 [a]	1490	161	1776 [ab]	1599	161	2036 [b]	1727	160	1681	1562	803	0.005 **
Eggs/Poultry/Pork	554	353	158	564	342	163	553	373	161	587	389	161	608	409	160	573	373	803	0.627
Fish	252	303	158	248	310	163	235	315	161	250	359	161	308	440	160	258	349	803	0.375
Processed Meat	271	354	158	255	372	163	330	417	161	299	363	161	373	418	160	306	387	803	0.047
Savories	161 [a]	216	158	161 [a]	245	163	224 [ab]	306	161	242 [ab]	338	161	288 [b]	479	160	215	333	803	0.001 **
High-Sugar Foods	225 [a]	167	158	256 [ab]	198	163	273 [ab]	176	161	306 [bc]	198	161	368 [c]	262	160	286	208	803	0.000 ***
Fats/Oils	234 [a]	232	158	286 [ab]	274	163	259 [a]	335	161	346 [ac]	378	161	381 [bc]	423	160	301	339	803	0.000 ***
Carbonated Beverages	186	284	158	187	330	163	163	267	161	264	423	161	268	480	160	214	368	803	0.024 *
Other Beverages	371	272	158	413	349	163	408	337	161	420	326	161	411	324	160	405	323	803	0.690
Alcohol	540	1045	158	544	881	163	460	818	161	560	834	161	671	1150	160	555	954	803	0.402
Miscellaneous	217 [a]	235	158	267 [ab]	291	163	249 [ab]	260	161	269 [ac]	276	161	320 [bc]	294	160	265	274	803	0.018 *

[a,b,c] Mean values with unlike superscript letters were significant different at the 0.05 level. There was no significant difference between any means in rows with no superscript letters.

*. Means are significantly different at the 0.05 level.

**. Means are significantly different at the 0.01 level.

***. Means are significantly different at the 0.001 level.

Discussion

This study found a direct and significant relationship between dietary GHGE and the level of relative EI in Irish adults. As Irish men and women consumed higher levels of food energy relative to their needs, the carbon footprint of diets increased considerably. On average, the highest relative energy consumers (Q5; mean EI:EER of 118.1%) had 11.4% more dietary carbon emissions in men and 11.7% in women compared to that of High Consumers (Q4; mean EI:EER of 98.4%). These results are consistent with those obtained by Vieux *et al.* (*2012)* in a sample of French adults, whereby their study estimated that reducing total caloric intakes to meet individual energy needs would lead to a 10.7% decrease in dietary GHGE.

Currently in the Irish diet, animal products contributed approximately 48.1% to total dietary GHGE, of which red meat contributed 22.4%, dairy 12.0% and eggs, poultry and pork 9.2%. While foods of animal origin were found to have high GHGE, they only constituted approximately a quarter of overall EI across the whole sample population. Hence, recommendations to reduce consumption of meat would have little or no impact on energy intake. A pan-European study examining the contribution of various food groups to overall dietary carbon emissions supported that animal products were the highest contributors to diet-associated carbon emissions for both genders in France, the United Kingdom, Italy, Finland and Sweden (excluding Finish women where dairy was the highest contributor (Vieux *et al.* 2018). Additionally, the researchers also found that foods of animal origin constituted a smaller proportion of total EI than of total GHGE across Europe, results that are consistent with the present study. However, patterns of dietary GHGEs in another study by Hyland *et al.* (2017b) using these data showed that the dietary pattern with the lowest overall dietary emissions, had the highest intake of red meat. This is very important to note that, although on a single food group basis meat has high associated emissions, in the context of an actual diet, its contribution is often significantly lower than expected. Eliminating animal product consumption may compromise the nutritional integrity of the average diet, since foods of animal origin contain many amino acids and nutrients that are beneficial for human health (Biesalski, 2005). If applied on a nationwide scale, this major dietary shift may have a variety of public health consequences (e.g. nutrient deficiencies) without any concurrent benefit of decrease in energy intake. Decreases in GHGE following a substantial reduction of animal product consumption also heavily depends on the foods that are used in its place (Perignon *et al.* 2017). Excessive consumption of discretionary foods has been shown to be a key driver of avoidable dietary-related greenhouse gas emissions (Hendrie *et al.* 2016) Significantly reducing these typically energy-dense foods may result in considerable health benefits at minimal environmental expense.

An alternative approach to mitigate dietary GHGE in Ireland may be to increase the adherence of the average Irish diet to dietary guidelines. Recent literature has shown synergies between what is environmentally and nutritionally beneficial (MacDiarmuid *et al.* 2012; Tilman & Clark 2015; Hendrie *et al.* 2016). Overconsumption was evident for a large proportion of the Irish population, a trend that is detrimental to the health status of the country (Harrington *et al.* 2001, IUNA 2011). The strategy of following dietary guidelines would prompt a decrease in overall food intake to match energy requirements and maintain a healthy body weight. Since the average per-capita EI is higher than needed, balancing EI and energy expenditure can result in less food being consumed, and hence less dietary GHGE. This approach would facilitate a nutritious and balanced diet, while having minimum impacts on the cultural acceptability and economic viability of the new diet. While sustainable consumption can significantly mitigate dietary GHGE, sustainable agriculture, food processing and retailing must also be addressed. This study found a strong positive association between dietary GHGE and the amount of food and calories consumed relative to one's needs amongst a representative sample of the Irish population. As men and women consumed higher levels of energy relative to their needs, the likelihood of high diet-associated GHGE increased. Hence, the development of dietary guidelines can easily incorporate strategies to concurrently address dietary climatic impact while also having a positive public health outcome.

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