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Climate Impacts of Food Purchases

A Carbon Footprint Assessment of High-Protein Foods for INSTITUTION

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On behalf of the Humane Society of the United States

DATE, YEAR

Introduction

The food system is closely and inextricably linked with the environment. Agriculture occupies half of all ice-free land on Earth, and the global food system is responsible for 34% of all greenhouse gas emissions (GHGs)[1]. As the human population and economy continue to grow, it will become ever more important to meet society's needs within the bounds of planetary sustainability.

Some foods have much larger environmental impacts than others. Animal products generally use more resources and cause more GHG emissions than plant foods[2]. In fact, a shift toward plant-based diets is one of the only options available to simultaneously improve society's carbon footprint, land use, and food security[3,4]. Institutions and individuals can make a real environmental difference by reducing meat consumption – all while improving health and reducing costs.

INSTITUTION's commitment to improving the availability of plant-based meals on campus provides an excellent opportunity to address climate change emissions from food. This report, based on three semesters of dining hall purchase data, shows how meat purchases contribute to the INSTITUTION's carbon footprint and how shifts toward plant-forward menus can reduce emissions.

Meat Purchases & GHG Emissions

INSTITUTION supplied data on the weight of high protein foods purchased over two semesters, Spring 2019 and Fall 2020, categorized by animal species and food type. The full data set contained 432 unique foods in 30 categories. These were consolidated into 16 categories of meat, dairy, eggs, and plant-based foods.

Greenhouse gas emissions of purchased plant and animal products were calculated using a "life cycle" approach that includes the energy and emissions required to grow crops and animal feed, as well as breed, house, transport, and process livestock at a slaughterhouse. Emissions from post-farm food storage, processing, packaging, and transportation to distribution centers are included using global

[1] Crippa, M., Solazzo, E., Guizzardi, D., Monforti-Ferrario, F., Tubiello, F. N., & Leip, A. (2021). Food systems are responsible for a third of global anthropogenic GHG emissions. Nature Food, 2(3), 198-209.
[2] Searchinger T, Waite R, Hanson C, Ranganathan J, and Dumas P. (2019) Creating a Sustainable Food Future: A Menu of Solutions to Feed Nearly 10 Billion People by 2050. Ed. Emily Matthews. World Resources Institute, Washington DC. https://www.wri.org/our-work/project/world-resources-report/world-resources-report-creating-sustainable-food-future
[3] IPCC (2019) Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. Summary for Policymakers. https://www.ipcc.ch/report/srccl/
[4] IPCC (2018) Global Warming of 1.5 °C: An IPCC special report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. https://www.ipcc.ch/sr15/

averages[5]. This life cycle emissions measurement approach is similar to the GHG Protocol Scope 3 carbon emissions standard[6]. Emissions are reported as carbon dioxide-equivalent emissions (CO_2e), a unit combining carbon dioxide, methane, nitrous oxide, and other GHGs on a common basis. All GHG emissions are adjusted according to their warming effect relative to carbon dioxide over 100 years. For more detailed information on calculations and data sources, see Appendix A.

The assessment covers more than 120 metric tons of INSTITUTION's high-protein food purchases, representing 1,030 metric tons of GHG emissions. Over both semesters, chicken was the highest-volume meat purchased in 2020, followed by beef and pork (Table 1). Combined, these three meats represent 49% of assessed purchases by weight and 71% of GHG emissions (numbers for beef include a very small number of lamb and mutton purchases). Dairy products also represented major purchase categories. Yogurt was the second-highest purchase category by weight in Fall 2020 at over 6 metric tons.

Table 1: Purchased weight (in kilograms), greenhouse gas (GHG) emissions (in carbon dioxide-equivalents), and total number of animals consumed for each reported food type for the most recent semester (Fall 2020). Totals and sums may appear to differ due to rounding.

	Purchases		GHG Emissions		Animals	
	kg	%	$kgCO_2eq$	%	#	%
Beef & Lamb	5,309	13.8%	180,000	53.2%	26	0.3%
Pork	4,372	11.4%	25,000	7.5%	62	0.8%
Poultry	10,839	28.2%	49,000	14.5%	6,249	78.9%
Fish	1,628	4.2%	12,000	3.6%	1,239	15.6%
Shellfish	18	0.0%	270	0.1%	168	2.1%
Eggs	4,907	12.8%	12,000	3.4%	177	2.2%
Milk	500	1.3%	1,200	0.5%	0	0.0%
Cheese	2,197	5.7%	36,000	10.9%	1	0.0%
Yogurt	6,294	16.4%	16,000	4.5%	0	0.0%
Plant-based Meat	141	0.4%	310	0.1%	0	0.0%
Plant-based Milk	96	0.3%	49	0.0%	0	0.0%
Plant-based Cheese	27	0.1%	65	0.0%	0	0.0%
Beans & Pulses	692	1.8%	1,200	0.4%	0	0.0%
Nuts & Seeds	29	0.1%	52	0.0%	0	0.0%
Tofu & Tempeh	554	1.4%	1,500	0.4%	0	0.0%
Mushrooms	781	2.0%	2,400	0.7%	0	0.0%
ANIMAL TOTAL	36,303	94.6%	370,000	98.4%	7,921	100.0%
PLANT TOTAL	2,084	5.4%	5,300	1.6%	0	0.0%
GRAND TOTAL	38,388	100.0%	370,000	100.0%	7,921	100.0%

[5] Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.
[6] For information on the GHG Protocol standards, see https://ghgprotocol.org/standards

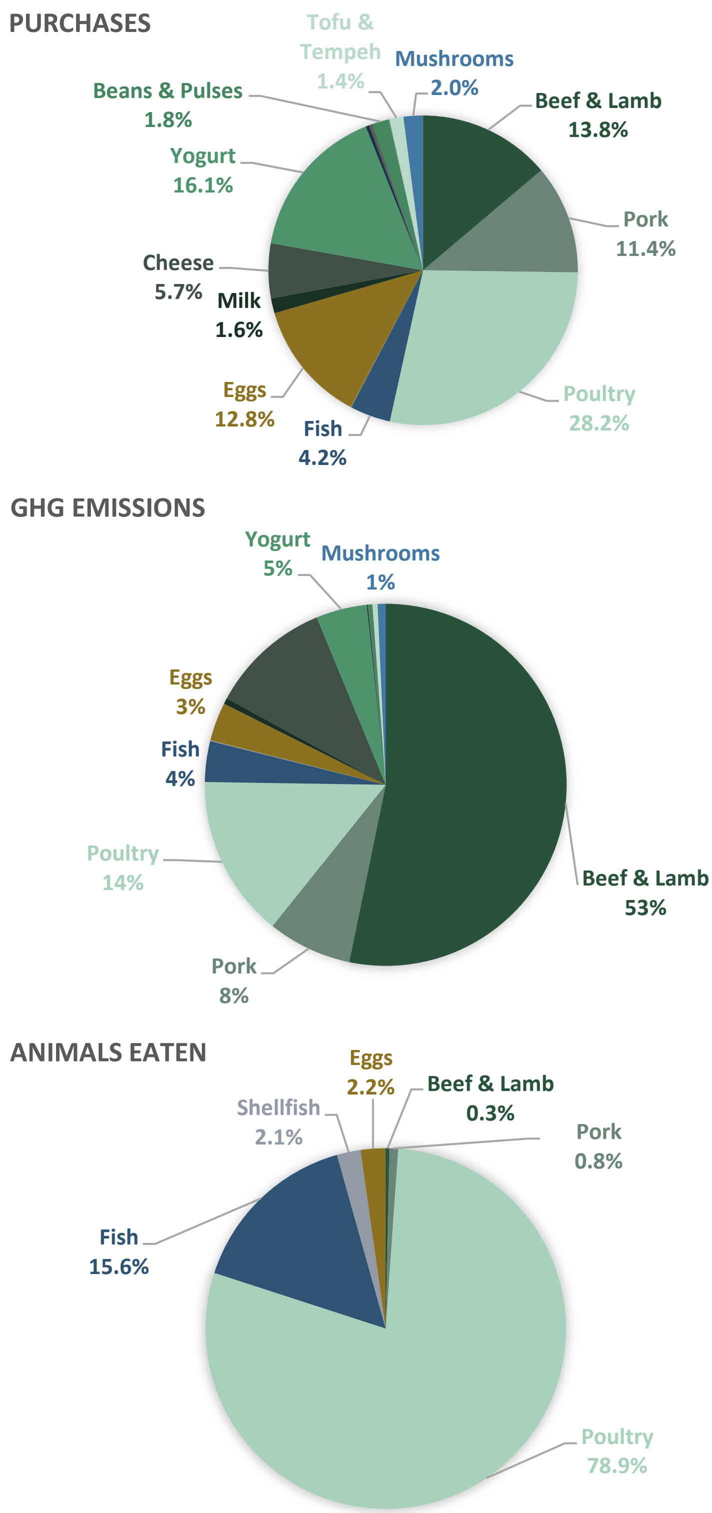

Figure 1: Proportions of food purchases, GHG emissions, and number of animals eaten by food category during the most recent semester (Fall 2020) at INSTITUTION. Food categories that represent less than 0.5% of total in each chart omitted for clarity.

Plant-based purchases were generally much lower volume than animal product purchases, representing only 5.4% by weight. Only two non-animal categories, mushrooms and beans and pulses, made the list of top 10 highest-volume purchases by weight in the most recent semester. (Though mushrooms are fungi, not plants, this report groups edible mushrooms with 'plant-based foods'.) While the INSTITUTION purchased over 140 kg (310 lbs) of plant-based meats in 2020, these amounted to just 0.1% of assessed purchases. Based on this assessment, INSTITUTION purchased more than 37 times more beef in Fall 2020 than plant-based meats. Less-processed plant foods like beans and tofu together represented just over 3% of reported purchases for the most recent semester.

Total GHG emissions from the assessed purchases in Fall 2020 was 340 metric tons, or more than 740,000 pounds of CO_2-equivalent emissions. That is equivalent to the emissions from driving 830,000 miles, or heating 40 homes for a year. It would take 400 acres of US forests to absorb that much CO_2 each year. It would cost about $27,000 to prevent 340 metric tons of emissions through solar power purchasing agreements, or $62,000 by replacing incandescent lightbulbs with LEDs.

More than half of INSTITUTION's assessed food purchase emissions come from beef (Figure 1). Beef, pork, chicken, and turkey combed account for 75% of all assessed emissions, but just half of purchases by weight. Plant-based products (meats, milks, beans, and others) were 6% of total purchases by weight but only 1.6% of emissions.

The number of animals used to supply INSTITUTION's assessed Fall 2020 food purchases – 7,900 – shows a much different pattern than the GHG footprint. Chicken and fish dominate the chart of total animals consumed, with smaller contributions by shellfish, chicken (for eggs), and pork (Figure 1). Animal size is an important factor in these calculations. Even though beef accounted for 14% of assessed purchases, they represented just 0.3% of animals consumed. Because poultry make up nearly 80% of purchased animals and also a substantial fraction of meat-related emissions, they make an excellent target for substitution with plant-based meat products. This information can help institutions justify and explain menu changes to students and other consumers, particularly as many individuals are becoming more interested in ethics and animal welfare issues.

GHG Hotspots: Highest-emitting products

Out of all individual products purchased, the three highest-emitting chicken products add up to about 7% of total GHG emissions. The most popular product, tempura nuggets, was responsible for 12 metric tons of CO_2 (Table 2). Other products, including bone-in chicken and 4-oz packages of chicken breasts generate 6.2 and 5.2 metric tons of CO_2, respectively.

Table 2: GHG Hotspots - Top 3 Emitting Chicken Purchases

Food Item	Rank (Chicken)	Rank (All foods)	Weight (kg)	GHGs (kg CO_2e)	GHGs (% Total)
Nuggets, Tempura	1	8	2966	12,000	3.5%
Bone-In	2	18	1571	6,200	1.9%
Breast, 4 oz	3	21	1315	5,200	1.6%

INSTITUTION purchased pork in smaller quantities than chicken products in Fall 2020.The top three purchases represent 6.6% of all purchases by weight, compared to 15% for the top three chicken products. These three pork products are responsible for 4% of total purchase emissions (Table 3).

Table 3: GHG Hotspots - Top 3 Emitting Pork Purchases

Food Item	*Rank (Pork)*	*Rank (All foods)*	*Weight (kg)*	*GHGs (kg CO_2e)*	*GHGs (% total)*
Bacon	*1*	*15*	1299	7,500	2.2%
Loin	*2*	*25*	714	4,100	1.2%
Sausage, Pattie 1.5 oz	*3*	*30*	539	3,100	0.9%

The three highest-emitting beef items represent 24% of the assessed food purchase emissions. Though beef was purchased at lower volume than the top three chicken products, the GHG emissions from each product were about three times as high (Table 4).

Table 4: GHG Hotspots - Top 3 Emitting Beef Purchases

Food Item	*Rank (Beef)*	*Rank (All foods)*	*Weight (kg)*	*GHGs (kg CO_2e)*	*GHGs (% total)*
Ground	*1*	*1*	998	32,109	9.6%
Hamburger Patties	*2*	*2*	844	27,147	8.1%
Julienne	*3*	*3*	599	20,861	6.2%

Combined, the dairy products assessed in this study account for the second-largest category of purchases by weight (23%) and the second-largest source of GHG emissions (16%). The three highest-emitting dairy products, shredded cheddar, vanilla Greek yogurt, and 1 lb solid butter, account for 11% of purchases by weight and 8% of all assessed GHG emissions (Table 6)

Students at Smith College in Massachusetts recently identified liquid milk purchases as a top candidate for substitution with plant-based options to reduce GHG emissions[7]. Many options for dairy milk replacement are available, with GHG emissions savings of 65% to 85%. A more detailed assessment of INSTITUTION's dairy purchases would help identify the best product candidates for substitution according to cost, convenience, and GHG emissions savings criteria.

[7] Chiang E, Ness AC, Duncan F, Towne K. (2020) Reducing Smith College's Dining GHG emissions: An analysis of beef and milk substitutions. Ed. Alex Barron, Dano Weisbord. AASHE https://hub.aashe.org/browse/publication/23333/Reducing-Smith-Colleges-Dining-GHG-emissions-An-analysis-of-beef-and-milk-substitutions.

Table 6: GHG Hotspots - Top 3 Emitting Dairy Purchases

Food Item	Rank (Beef)	Rank (All foods)	Weight (kg)	GHGs (kg CO_2e)	GHGs (% total)
Cheddar, Shredded	1	7	816	13,533	4.0%
Yogurt, Greek	2	17	3156	7,643	2.3%
Butter, Solid 1lb	3	24	376	5,058	1.6%

Overall, the top three purchases in each high-impact category (beef, pork, and poultry, and dairy) combined make up 40% of all assessed purchases by weight and 43% of GHG emissions. This provides an opportunity for INSTITUTION to examine new recipes or substitutions for these products. Replacing just the 12 ingredients on these lists with low-emissions plant foods could help INSTITUTION reduce food purchase emissions by about 34%.

Recent Changes in Food Purchases

INSTITUTION supplied food purchase data for two semesters, allowing for an assessment of recent changes in purchasing. Overall, GHG emissions followed trends in food purchases, which decreased in Fall 2020. However, a 33% increase in beef purchases between Spring 2019 and Fall 2020 drove an rise in total GHG emissions, despite decreases in all other animal meats, eggs, milk, and cheese (Figure 2). The largest overall change in purchasing was an increase in yogurt purchases, which rose 7,634 lbs (127%) between Spring 2019 and Fall 2020. That represents a GHG emissions increase of nearly 8 metric tons (over 17,000 lbs CO_2).

Several plant food categories had dramatic percentage changes in purchasing, but with much smaller impacts on total volume or GHG emissions. INSTITUTION purchased 160% more plant-based meat, 43% more plant-based milk, and 1400% more plant-based cheese in Fall 2020 than Spring 2019. However, these changes amount to only 310 lbs of new plant-based food purchases. At the same time, purchases of beans and pulses dropped 23% (nearly 500 lbs), and purchases of tofu and tempeh decreased 22% (340 lbs).

In terms of providing plant-based protein options, the INSTITUTION's gains in plant-based meat, milk, and cheese products are more than offset by decreases in purchases of whole-foods plant proteins. In total, animal protein purchases decreased 2% (1900 lbs) between Spring 2019 and Fall 2020 semesters, while plant protein purchases decreased 22% (1300 lbs). Reversing this trend by purchasing more overall plant proteins - and increasing the proportion of plant-based proteins to animal protein foods – will be crucial to meeting INSTITUTION's dining sustainability goals.

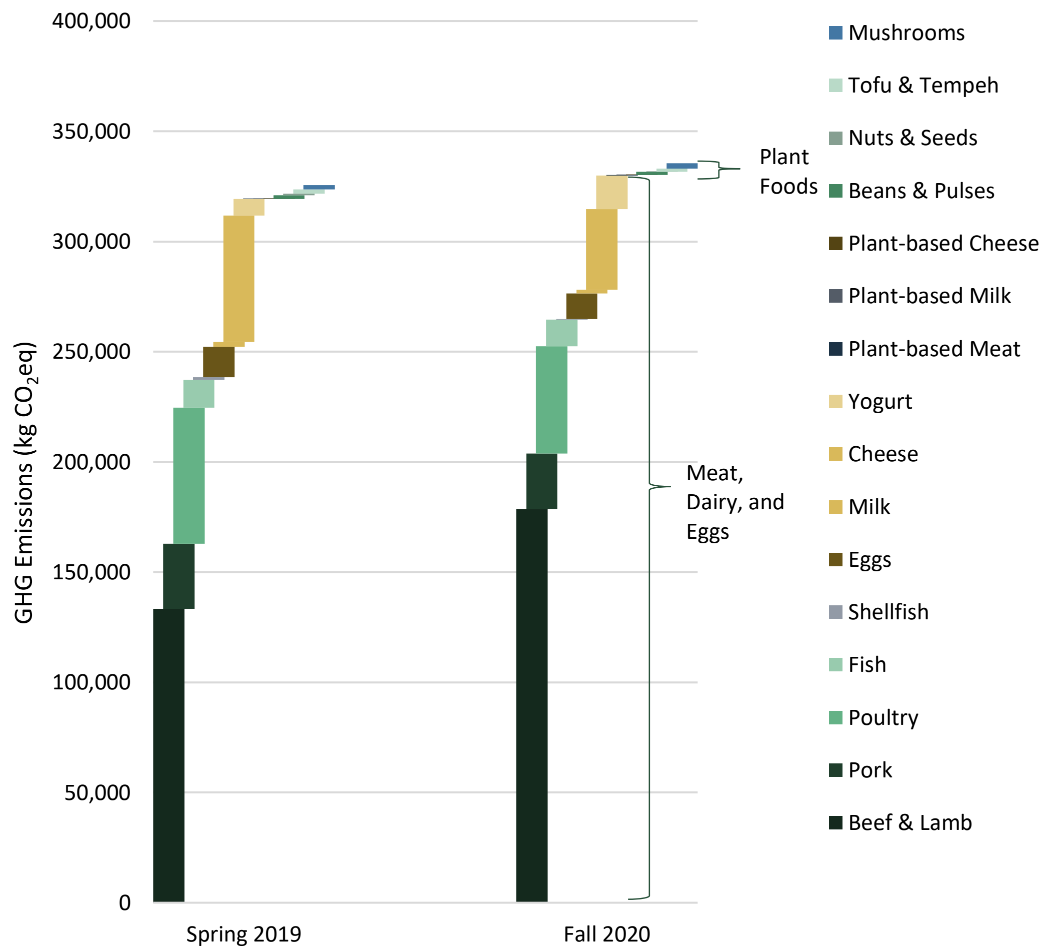

Figure 2: GHG emissions from assessed food purchases by INSTITUTION over two semesters, by category. From bottom: beef, lamb, pork (dark green shades), poultry, fish, shellfish (light green shades), eggs, milk, cheese, yogurt (gold shades), and plant foods (green and blue shades, top).

GHG Savings Potential

INSTITUTION has an opportunity to dramatically reduce its GHG emissions through menu changes. Replacing animal products with plant-based foods can substantially improve the carbon footprint of meal service. Plant forward dishes can reduce the GHG emissions of even lower-emitting meat products by over 80%. Animal to plant protein shifts also have numerous unique co-benefits, resulting in lower water, pesticide, fertilizer and land use[8,9]. There are also numerous health co-benefits related to animal

[8] Sabaté J, Sranacharoenpong K, Harwatt H, Wien M, Soret S. (2015) The environmental cost of protein food choices. Public Health Nutr. 18 (11):2096.

[9] Eshel G, Shepon A, Makov T, Milo R (2014) Land, irrigation water, greenhouse gas, and reactive nitrogen burdens of meat, eggs, and dairy production in the United States. Proc Natl Acad Sci 111:11996–12001

to plant protein shifts. For example, the consumption of 100 g unprocessed red meat per day relates to a 19% increased risk of type 2 diabetes[10], a 21% higher stroke risk[11], and a 17% increased risk of colorectal cancer[12]. Substituting just one serving per day (84 g) of unprocessed red meat with one serving of foods including legumes is associated with a 7-19% lower mortality risk[13].

Replacing animal sourced meats with plant sourced foods provides more GHG savings than using lower-carbon animal meats (such as switching from beef to chicken) and allows for more menu variety. For example, replacing the three highest-emitting animal products of each type (beef, pork, and chicken) with meat analogs (plant-based products that look and taste like animal meat) could cut GHG emissions by up to 91 metric tons per year (Table 7). Replacing those meats with beans, peas, or other high-protein plants increases the emissions reduction to 110 metric tons annually, or 91%. Achieving the same emissions reductions through solar power purchase agreements would likely cost the INSTITUTION $8,600 per year, or more than $20,000 from installing LED light bulbs.

Table 7: GHG emissions reductions from replacing 3 highest-emitting products of each meat type with meat analogs or beans and pulses. Totals and sums may appear to differ due to rounding.

	Meat Analog (kg CO_2e)	Emissions Reduction (%)	Pulses & Beans (kg CO_2e)	Emissions Reduction (%)
Beef	-74,000	93%	-78,000	98%
Pork	-8,400	57%	-13,000	88%
Chicken	-8,800	38%	-19,000	82%
TOTAL:	-91,000	77%	-110,000	91%

These emissions reductions are a best-case scenario, using the low-emissions alternative products. Some beef and chicken meat analogs that have recently been highly successful in the United States have somewhat higher emissions (3-8 kg CO_2e per kg, compared to 2-3 kg CO_2e per kg for low-emitting products). This difference is not substantial when comparing meat analogs to beef, lamb, and other high-emissions meats, but it does affect the emissions reductions when substituting these products for chicken or pork. Replacing chicken with some of these higher-emitting meat analogs could result in minor emissions reductions or even increase emissions[14]. These meat analogs still provide

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10 Pan A, Sun Q, Bernstein AM, et al. (2011) Red meat consumption and risk of type 2 diabetes: 3 cohorts of US adults and an updated meta-analysis. The American Journal of Clinical Nutrition 94:1088-96.

11 Micha R, Wallace SK, Mozaffarian D. (2010) Red and processed meat consumption and risk of incident coronary heart disease, stroke, and diabetes mellitus: a systematic review and meta-analysis. Circulation 121:2271-83.

12 Bouvard V, Loomis D, Guyton KZ, et al. (2015) Carcinogenicity of consumption of red and processed meat. The Lancet Oncology 16:1599-1600.

13 Pan A, Sun Q, Bernstein AM, et al. (2012) Red meat consumption and mortality: results from 2 prospective cohort studies. Arch Intern Med 172:555-63.

14 Based on reported carbon footprints of 2.1 and 5.8 kg CO_2e/kg for chicken nugget analogs from Mejia MA, Fresan U, Harwatt H, et al. (2019) Life Cycle Assessment of the Production of a Large Variety of Meat Analogs by Three Diverse Factories. J Hunger & Env Nutrition. DOI: 10.1080/19320248.2019.1595251; and Dettling, J, Tu Q, Faist M, DelDuce A, and Mandlebaum S. (2016) A Comparative Life Cycle Assessment of Plant-Based Foods and Meat Foods. Quantis USA.

environmental benefits by reducing land use and improving water quality, and their carbon footprints will decrease as the electricity used to process them becomes more renewable. Meanwhile, replacing meats with pulses, beans, and other whole foods is the most reliable – and healthful – way of reducing GHG emissions from food.

Eliminating meat purchases across all dining halls is a daunting task, despite the benefits. But reducing meat consumption by as little as 20% can also make a large impact. Based on the assessed Fall 2020 purchases, a 20% reduction across all meat purchases (and replacement with equally appetizing whole plant meals) would generate 52 metric tons (110,000 lbs) of GHG savings. With the large – and growing – percentage of vegetarians and "flexitarians" around the country, a 20% shift from meat to whole-plant meals may not be difficult to achieve.

GROUND MEAT SUBSTITUTION

Another way of identifying effective, easy targets for recipe substitutions is to look at ground and processed meat purchases. Ground meats are often used in burgers, sauces, and mixed meat-and-vegetable dishes with easy vegetarian alternatives. A wide variety of plant-based burgers are available, ranging from new products almost indistinguishable from beef to healthier minced vegetable patties. Swapping ground meat for plant-based meat analogs, vegetables, or tempeh in other recipes can even boost flavor while reducing GHG emissions.

In Fall 2020, INSTITUTION purchased nearly 15,000 lbs (6.8 metric tons) of ground and processed meat. This included 4,000 lbs of ground beef, 2,700 lbs of pork sausage, and 8,100 lbs of ground and processed poultry, amounting to almost a 18% of all protein food purchases. The GHG emissions from ground meat – 84 metric tons – were 25% of total protein food emissions.

Replacing ground meats with plant-based meat analogs would reduce the INSTITUTION's food purchase emissions by 67 metric tons. That is equivalent to driving 170,000 miles, or all of the carbon stored by 83 acres of US forest each year, or about 50 football fields. While switching to plant-based meats could be cost-neutral, achieving the same GHG emissions reduction with solar power purchase agreements could cost the INSTITUTION $5,500 per year.

Replacing ground meats with beans, pulses, or other high-protein whole plant foods could be even more climate-friendly. Substituting beans or lentils in ground meat recipes would reduce total emissions from all protein foods by 24%, saving 80 metric tons of CO_2. That is equivalent to driving more than 200,000 miles, powering over 10 homes for a year, or the carbon stored by 100 acres of US forests in a year. Achieving the same GHG reductions with solar power purchase agreements could cost the INSTITUTION $6,400 per year, while serving beans, lentils, and other high-protein plant foods can actually reduce costs.

Conclusions

INSTITUTION has an opportunity to reduce its carbon footprint by over 2000 metric tons each semester by transitioning to a more plant-forward dining service. GHG emissions from high-protein food purchases totaled 330 metric tons in the fall Fall 2020, an increase of 5 tons from Spring 2019. The three highest-volume meats (chicken, beef, and pork) are responsible for more than 75% of the emissions of all assessed foods. The three highest-volume products purchased in each meat category (plus dairy) represent 40% of all high-protein food purchases, making them prime targets for substituting with plant-based ingredients. Alternatively, focusing on easily replaced ground meats would allow the INSTITUTION to target over 25% of GHG emissions from just 18% of purchases by weight. Reducing animal product purchases by 20% and using plant-based alternatives would reduce emissions by 52 tons of CO_2 and spare 6,300 animals from the food system each semester.

This analysis provides a baseline for INSTITUTION's high-protein food purchases, emissions, and animal impacts. The data and case studies should serve as inspiration for improvement and setting goals for short-term and long-term improvement in climate change impacts, healthful dining, and animal welfare. For example, a long-term goal of reducing emissions from high-protein food purchases by 50% would guide replacement of certain meat and meal types with convincing plant-based meats and heart-healthy whole-foods dishes. Focusing on the "GHG hotspots" identified in this report could guide short-term emissions reduction goals by replacing a certain fraction of ground meat and whole meat foods in just one or two years.

To put INSTITUTION's meat-related emissions in perspective, consider the potential long-term goals of a 50% GHG emissions reduction from transitioning high-protein foods purchases from animal to plant foods. This would create a 260 metric ton annual GHG savings. That is equivalent to taking 30 cars out of service or switching 10,000 light bulbs to LEDs[15]. Achieving the same reduction by investing in renewable energy would require purchasing an additional 680 MWh of green power at a cost of roughly $10,000 per year[16]. Case studies show that dining halls can make these beneficial changes at negligible cost – or even with cost savings[17].

KEY TAKEAWAYS

1. The 12 highest-volume meat and dairy purchases account for 25% of GHG emissions, providing the largest opportunities for emissions reductions through product substitution with plant-based alternatives.
2. 32% of GHG emissions from meat purchases come from ground meats. Replacing these with similar-tasting plant-based products could reduce GHG emissions by 130 metric tons per year.
3. A goal of reducing GHG emissions from animal products by 50% could save 260 metric tons of emissions each year, potentially saving over $10,000 in annual renewable energy costs.

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[15] Estimated using the EPA Greenhouse Gas Equivalencies Calculator: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

[16] Estimated using DTE Energy's Environmental Impact Calculator: https://newlook.dteenergy.com/wps/wcm/connect/dte-web/quicklinks/migreenpower

[17] Kari Hamerschlag and Julian Kraus-Polk. (2017) Shrinking the Carbon and Water Footprint of School Food: A Recipe for Combating Climate Change. A pilot analysis of Oakland Unified School District's Food Programs. Friends of the Earth, Washington DC. https://foe.org/resources/shrinking-carbon-water-footprint-school-food/

Appendix A: Life Cycle Greenhouse Gas Emissions Factors

Table A1: Greenhouse gas emissions from foods. Values are shown on an edible weight basis, which may differ from the values reported in the original sources (see live weight and edible weight conversion factors in Table B1).

Food	*kg CO_2e / kg edible*	*Primary Source*
Beef (ground)	32.2	Rotz, C. A., Asem-Hiablie, S., Place, S., & Thoma, G. (2019). Environmental footprints of beef cattle production in the United States. Agricultural systems, 169, 1-13.
Beef (beef herd)	34.8	Rotz, C. A., Asem-Hiablie, S., Place, S., & Thoma, G. (2019). Environmental footprints of beef cattle production in the United States. Agricultural systems, 169, 1-13.
Pork	10.2	North American subset from: Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.
Chicken	4.89	North American subset from: Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.
Turkey	8.4	Nemecek, T., Bengoa, X., Lansche, J., Roesch, A., Faist-Emmenegger, M., Rossi, V., ... & Riedener, E. (2019). World Food LCA Database.
Duck	8.4	Assume same as turkey
Lamb & Mutton	26.3	Nemecek, T., Bengoa, X., Lansche, J., Roesch, A., Faist-Emmenegger, M., Rossi, V., ... & Riedener, E. (2019). World Food LCA Database.
Milk	2.4	North American subset from: Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.
Cheese	16.6	North American subset from: Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.
Cream	5.6	Nemecek, T., Bengoa, X., Lansche, J., Roesch, A., Faist-Emmenegger, M., Rossi, V., ... & Riedener, E. (2019). World Food LCA Database.
Butter	13.5	Nemecek, T., Bengoa, X., Lansche, J., Roesch, A., Faist-Emmenegger, M., Rossi, V., ... & Riedener, E. (2019). World Food LCA Database.
Yogurt	2.4	Assume same as milk
Eggs	2.3	Pelletier, N., Ibarburu, M., & Xin, H. (2014). Comparison of the environmental footprint of the egg industry in the United States in 1960 and 2010. Poultry science, 93(2), 241-255.
Fish	7.7	Clune, S., Crossin, E., Verghese, K., 2016. Systematic review of greenhouse gas emissions for different fresh food categories. Journal of Cleaner Production. Volume 140, part 2. pp766-783. Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.
Shrimp	14.9	Clune, S., Crossin, E., Verghese, K., 2016. Systematic review of greenhouse gas emissions for different fresh food categories. Journal of Cleaner Production. Volume 140, part 2. pp766-783.
Tuna, canned	7.1	AGRIBALYSE 3.0 (2019) https://doc.agribalyse.fr/documentation-en/
Pulses/beans	1.8	North American subset from: Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.
Tofu	2.9	North American subset from: Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.

Veg Oil	1.9	Nemecek, T., Bengoa, X., Lansche, J., Roesch, A., Faist-Emmenegger, M., Rossi, V., ... & Riedener, E. (2019). World Food LCA Database.
Nut milk	0.4	Clune, S., Crossin, E., Verghese, K., 2016. Systematic review of greenhouse gas emissions for different fresh food categories. Journal of Cleaner Production. Volume 140, part 2. pp766-783.
Soy milk	0.6	North American subset from: Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.
Vegan margarine	2.4	Nemecek, T., Bengoa, X., Lansche, J., Roesch, A., Faist-Emmenegger, M., Rossi, V., ... & Riedener, E. (2019). World Food LCA Database.
Meat analogs	2.2	Mejia et al. 2019 Life Cycle Assessment of the Production of a Large Variety of Meat Analogs by Three Diverse Factories
Impossible	3.5	Khan, S., Dettling, J., Loyola, C., Hester, J., & Moses, R. (2019). Environmental Life Cycle Analysis: Impossible Burger 2.0. Impossible Foods.
Beyond	3.5	Heller, M. C., & Keoleian, G. A. (2018). Beyond Meat's Beyond Burger Life Cycle Assessment: A detailed comparison between.

Appendix B: Conversion Factors

Table B1: Live weight to edible and cooked weight conversion factors used to adjust emissions and purchase values.

Animal	Live Weight		Edible Weight		Edible:Bone-in ratio		Cooked Yield		Animals per Edible kg
Beef	604	kg	224	kg	83%	%	74%	%	0.004
Chicken	2.8	kg	1.6	kg	77%	%	74%	%	0.64
Duck	3.1	kg	1.7	kg	77%	%	74%	%	0.58
Lamb	61	kg	22	kg	78%	%	65%	%	0.046
Pork	126	kg	71	kg	81%	%	78%	%	0.014
Turkey	14.4	kg	8	kg	77%	%	73%	%	0.12
Fish (average)	3.2	kg	1	kg	85%	%	77%	%	0.788
Clam	0.5	kg	0.2	kg	29%	%	86%	%	6.386
Crab	0.7	kg	0.3	kg	70%	%	88%	%	3.674
Salmon	4.5	kg	1.8	kg	85%	%	77%	%	0.55
Scallop	0.3	kg	0.1	kg	40%	%	88%	%	9.259
Shrimp	0.3	kg	0.1	kg	40%	%	88%	%	9.259
Tuna	249.5	kg	100	kg	85%	%	77%	%	0.010