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Written by Ann Gerhardt, MD

Diet for a Healthy Planet
by Ann Gerhardt, MD *October 2021*

Bottom Line at the Top: Eat more plant foods and less animal foods, especially beef, to reduce greenhouse gases that cause climate change. What we eat has a greater impact on emissions than does where it was produced, though both contribute to the problem. Read on for details about how food production contributes to greenhouse gas emissions.

Growing, processing, packaging, transporting, and preparing food generate greenhouse gases (GHG) that damage the atmosphere. Just choosing locally grown food doesn't come near to solving the problem, because GHG emissions from food transportation are far exceeded by emissions from animals (especially cows), nitrogen-containing fertilizer, powering farm and food processing machinery, deforestation and burning plant residue.

Various organizations estimate that agriculture, from origin to fork, contributes between 10 and 26 percent of total global GHGs. Regardless of the exact numbers, all agree that agriculture has a significant impact on GHG production, with beef and dairy cattle contributing far more greenhouse gases per kilogram (kg) of food than any other food source.

The U.S. Environmental Protection Administration figures that beef cattle accounts for 37%, dairy cattle for 11.5%, swine for 4.4% and poultry for 0.6% of total food-related GHG generation. The rest comes from the totality of plant food production across the globe. Except for chocolate and coffee, whose production generates almost as much GHG as does pig meat, plant foods generate very little GHG per kg of food. The only foods that come close to reducing GHG by pulling carbon dioxide (CO_2) out of the air are tree foods, like nuts and fruit, but their farming, cooling, packaging and transport generate some net GHG.

The people who do these calculations consider more than CO_2 generation in their calculations. CO_2 comprises 76% of global GHG emissions but is the least potent. Smaller amounts of nitrous oxide, methane, hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride are much more potent and have an outsized global warming potential, as shown in the table below. For that reason, scientists report GHG in kilograms of CO_2 "equivalents", or CO_2e, which takes into account different GHGs' potency.

Greenhouse Gas (GHG)	Percent of total GHG	Average atmospheric lifetime	100-year global warming potential compared to CO_2
CO_2	76%	Long, but variable, depending on transfer to land & sea	1
Methane	16%	12.4 years	28-39
Nitrous oxide	6%	121 years	265-298
Fluorinated gases	2%	Weeks to 1000s of years	Varies up to 23,500

A large part of GHG production from agriculture is nitrous oxide and methane from ruminant cow digestion and animal waste, and nitrous oxide from fertilizers. Burning crop residues produces CO_2, methane and nitrous oxide. Using fossil fuels to power farm machinery, cooling, transportation and processing emits CO_2.

The OurWorldinData organization published a graph of greenhouse gas emissions across the food supply chain (https://ourworldindata.org/food-choice-vs-eating-local). They quantified the proportion of emissions caused by changing land

use (mostly deforestation), farming, producing animal feed, processing, transport, retail and packaging. Cattle for beef consumption, at 60 kg CO_2e per kg of product, generates more than double the GHG as other animal food sources, including dairy cows and sheep. After those high-GHG emitting producers, in order of decreasing CO_2e, pig meat, poultry meat, fish and egg production generate much less GHG (between 7 and 3 kg per kg of product.)

Cattle exhale CO_2, generate and burp GHG during digestion, produce GHG-producing manure and urine, and use fossil fuel for refrigeration and transport to market. If they eat grain feed, add GHG resulting from nitrogen-containing fertilizers, deforestation, processing and transportation.

Cattle emit excess GHG during digestion because they don't have all the digestive enzymes necessary to break down grass and plant roughage. To accomplish digestion, it takes bacteria to turn plants into usable nutrients as well as four sequential stomachs, each with a special purpose. After chewing food and swallowing, undigestible metallic or heavy material drops into the first stomach to bypass digestion and the rest passes to the second stomach, the rumen. They regurgitate it back into their mouths, chew the "cud" and swallow it again and again, up to 40% of their day, depending on the food source. The rumen churns the pulpy food, mixing it with fermenting bacteria, which break down plant material to absorbable fatty acids they use for calories. Any remaining material passes into the last two stomachs and small intestine for further digestion and final nutrient absorption.

In addition to nutrients, fermentation in both the rumen and colon yields CO_2 and methane, which cattle belch and fart into the air. Manure and urine also contribute GHGs: Waste products in each are fermented by soil bacteria, generating methane and nitrous oxide.

Some companies have created novel methods to reduce cattle's GHG emissions. One makes cattle masks that capture exhaled and burped GHGs and dispose of them safely. Another group has trained cattle to pee into a confined space, so urine nitrogen doesn't combine with soil and air to make ammonia and nitric oxide. Those plans seem unlikely to scale up to thousands of cattle across the world but they get points for ingenuity. A more practical plan is to use manure as plant fertilizer, at times for animal feed on the same farm, reducing the necessity for fossil fuel-intense fertilizer production. However, how manure is stored and applied makes a big difference in its own GHG generation.

No one can stop cattle from burping, breathing, farting, stooling and urinating (they would blow up). So we need super-efficient waste management and GHG capture and currently energy intensive conversion to a non-gaseous substance, or we stop consuming beef and dairy foods.

What about other animals? Fossil fuel utilization, powering heated chicken coops, farm machinery and transport to market, makes up the bulk of emissions in the poultry industry. Birds also breath out CO_2 and require food, the production of which generates GHGs but, compared to cattle, GHG emission is small. If poultry farmers were to satisfy their energy needs with electricity from renewable sources instead of fossil fuels and produce feed locally using the birds' manure for fertilizer, poultry would be one of the least climate-impactful foods.

Food production for a plant-based diet is better for the planet, since it entails less GHG emission than does an omnivorous diet, especially one full of beef. But it is not GHG emission free. Crop land too often comes from deforestation, causing fewer trees pull CO_2 out of the air. Using fossil fuels for farm machinery, cooling, processing and transport generates CO_2. Stagnant or burned crop residues generate CO_2, methane and nitrous oxide. One of the greatest sources of GHG in food crop agriculture is nitrogen-containing fertilizer.

U.S. farmers use mega-tons of fertilizer each year, containing 11.5 million metric tons of nitrogen that plants need to grow. Just producing it requires fossil fuel. Fertilizer's nitrogen generates potent GHG nitrous oxide upon contact with soil and air, especially with excessive, inefficient use. Farmers could reduce nitrous oxide emissions just by using lighter applications more often. They also could obviate the need for fertilizer by using manure generated locally. A new company named Nitricity

designs solar-powered units for farms to make their own nitrogen-based fertilizer and deliver it minimally and efficiently in an irrigation system. These approaches would reduce agriculture's climate impact.

Switching the purpose of land from grazing and growing feed to growing human food would feed billions more people with far less impact on climate change than we currently do, assuming we can get it to them. About ten percent of the world's population is, to some degree, vegetarian by choice. Many of them eat occasional poultry, dairy and fish in addition to the plant protein foods, legumes, seeds, nuts and whole grains. We don't need heavy animal protein diets. People in many other countries consume far less animal foods than Americans and live productive, healthy lives.╣