What is your dinner doing to the climate?

11 September 2008 by Bijal Trivedi

Issue 2673 of New Scientist magazine

LOCAL or imported? Conventional or organic? Can you make choices that will keep your diet healthy and reduce your carbon footprint? Is it possible to eat green? Does it even matter?

It may surprise you to learn that our diets account for up to twice as many greenhouse emissions as driving. One recent study suggested that the average US household's annual carbon food-print is 8.1 tonnes of "equivalent CO2 emissions" or CO2eq (a measure that incorporates any other greenhouse gases produced alongside the CO2). That's almost twice the 4.4 tonnes of CO2eq emitted by driving a 25-mile-per-US gallon (9 litres per 100 kilometres) vehicle 19,000 km - a typical year's mileage in the US.

As greenhouse gas emissions attract ever greater scrutiny and criticism, the fields of sustainable consumption and life-cycle carbon accounting have prompted academics to tally the greenhouse gas emissions of hundreds of products and manufacturing processes so that we can make more environmentally friendly food choices.

In the UK some supermarkets have already begun pilot programmes to label foods with their carbon footprint. One potato crisp producer is now labelling some lines with their CO2eq footprint - the makers calculated that each 34.5-gram packet that leaves the factory accounts for 75 grams of CO2eq. The Carbon Trust, a campaign group based in London, is working on a standardised system that companies can follow to work out the CO2eq footprint of any product.

So how do you calculate your stomach's CO2eq footprint? It's far from simple. For a start, you have to analyse every joule of energy used, from farm to fork, to measure its greenhouse gas contribution. Food produced using wind or solar power will produce lower emissions than food reliant on gas or coal, for example. For meat and dairy produce you also have to account for methane and nitrous oxide emissions - both potent greenhouse gases.

Methane remains in the atmosphere for 9 to 15 years and traps heat 21 times as effectively as CO2. Fertilisers and manure release nitrous oxide, which is 296 times as good as CO2 at trapping heat and remains in the atmosphere for 114 years on average. A food's emissions total also depends heavily on where it grew and how it was transformed from raw ingredients into your dinner. This includes gases generated by tilling the land, sowing the crops, making fertilisers and pesticides, harvesting the food and shipping it to processing plants, as well as electricity for cleaning, processing and packing your food, and then transporting it to your store. Finally, the loss of carbon sinks when forests are cleared for grazing or crops has to be accounted for.

The calculations can become "fiendishly complicated", says Astrid Scholz, an ecological economist at Ecotrust, a think tank based in Portland, Oregon. Scholz led the development of a carbon calculator for the Bon Appétit Management Company Foundation, which developed a Low Carbon Diet for its 400 plus cafeterias in the US.

For example, to calculate the CO2eq impact of eating an industrially raised chicken breast, you would factor in the following. First, there's the emissions from preparing the feed pellets. This would include the fertiliser, growing and processing the grain, and finally transforming it into bite-sized pellets that will feed the chicken while it sits

in a hut with 250,000 other birds. Add to that the energy for heating the structure, the fuel for transporting the chicken to the slaughter facility, and the emissions from running the slaughtering facility and manufacturing the packaging.

Then there are emissions from transporting the animal to the wholesaler, the refrigeration costs of storing the meat, the trip to the retailer, and further refrigeration in the shop. Then you drive to the store, buy your chicken, drive home and cook it - all those emissions count too. Chicken is a relatively simple example, but the more stages involved in a food's production, the harder it becomes to calculate its true CO2eq footprint.

Scholz found that until recently there had been no wide scale effort to calculate CO2eq for foods in the US. In Europe, however, there are fledgling programmes that have calculated CO2eq emissions for some foods, so she used these figures to create a carbon calculator that she says gives comparable figures for the US. "We took a Dutch chicken farm and plopped it in Texas and assumed that it worked in a similar way," she explains.

She describes the resulting carbon calculator as "version 1.0 of a good idea". It doesn't give you the derivation of the figures, but it will tell you that 333 grams of CO2eq is emitted to make one hard-boiled egg. Compare that with a bowl of cereal with milk: 1224 grams of CO2eq - equivalent to driving a typical SUV 6 km.

The main culprit in the bowl isn't the cereal, it's the milk. That's because the most emissions-intensive foods are red meat and dairy products. In general, red meat emits 2.5 times as much greenhouse gas as chicken or fish, since rearing cows and other livestock requires a lot of energy. It takes 2.3 kilograms of grain to make every kilo of chicken meat, 5.9 kg of grain for a kilo of pork, and 13 kg of grain plus 30 kg of forage for a kilo of beef. Worse still, they produce methane and their manure releases nitrous oxide.

However, Peter Tyedmers, an ecological economist at Dalhousie University in Nova Scotia, Canada, warns that such calculators should be taken with a pinch of salt. Tyedmers and his students provided much of the raw data for the calculator, and while he agrees it is a good idea in principle, he says the figures they came up with are specific not just to the precise types of foods they measured, but to every detail of where and how they were produced, so cannot be generalised. For example, regional differences in farming practices can make a big impact on the final figure, he says. Simply changing an animal's feed can have a huge impact on its CO2eq footprint too. "It's all very fluid," says Tyedmers. "There's a tremendous hunger for these sorts of numbers and this has created the assumption that any existing figures are robust. They're not."

Tricky as it may be, some general rules are emerging that can guide you towards a less carbon-intensive diet. One sure-fire way of reducing your CO2eq footprint is to go vegetarian. Gidon Eshel and Pamela Martin, at the University of Chicago, calculated that switching from the average American diet to a vegetarian one could cut annual emissions by almost 1.5 tonnes of CO2eq per person.

Switching from the average American diet to a vegetarian one could cut emissions by 1.5 tonnes of CO2eq per person

If you can't face life without steak, there might soon be an alternative source of meat that can still dramatically cut your CO2eq emissions: in vitro meat. Animal-rights organisation People for the Ethical Treatment of Animals (PETA), which promotes

vegetarianism, is offering a $1 million prize for an industrial-scale means of making in vitro chicken meat with a taste and texture indistinguishable from the real thing.

Careful dietary choices can also make a big difference to your greenhouse gas emissions. For example, you may well think that eating local or organic produce are greenhouse-friendly options, but that's not always the case. Even different fish have a wide variety of greenhouse impacts.

Christopher Weber at Carnegie Mellon University in Pittsburgh, Pennsylvania, also examined whether vegetarians eat enough nutrients. His conclusion was a resounding yes. "Plant-based diets are safe, and are probably nutritionally superior to mixed diets deriving a large fraction of their calories from animals," he wrote. The message is clear: indulge in a steak once in a while, but our planet's health would be better off if we just give meat the chop.

1 Meat or not?

When it comes to foods with the highest potential for global warming, red meat products are among the worst. Livestock account for 18% of "man-made" greenhouse emissions: 9% of all CO2, 35 to 40% of methane and 65% of nitrous oxide (mainly through fertilisers).

Ruminants such as cattle, goats and sheep not only breathe out CO2 like us, but they also produce methane. The cause is lignin, a component of the cell wall in grass that can only be digested with the help of bacteria in the animal's gut, and the unfortunate by-product of this is methane. What's worse, the resulting excrement also releases methane as the undigested plant matter decays. Spreading the waste on fields or pastures can minimise this, but the manure is often stored in liquid form in large lagoons, which exacerbates the anaerobic decomposition. Some farms tackle this by covering the lagoons and trapping the methane, which is burned to provide heat.

Can the animals' diet make a difference? Grass-fed beef is frequently marketed as the cleaner, greener alternative to grain-fed cattle because the cows don't consume energy-intensive crops. However, this is misleading according to Ermias Kebreab at the University of Manitoba in Winnipeg.

Kebreab and his colleagues developed a computer model of the cow's digestive system and simulated whether grain or grass produced the most methane. Then he tested his predictions by placing a cow in a room, feeding it either corn or hay, and measuring the rising levels of CO2 and methane every minute for 24 hours. He found that grass-fed cows actually produce more methane than the grain fed ones.

"Cows evolved to eat grass, but these grass-fed cows produce less milk and meat than their grain-fed counterparts," says Kebreab, so you need to rear more to produce the same amount of food. Higher-quality feed like corn builds a more productive cow that yields more meat and milk and produces less methane.

It matters because meat and dairy products make up a third of humanity's protein intake, and demand is growing fast. In 2000, global meat consumption was 230 million tonnes per year; by 2050 it is expected to reach 465 million tonnes. What's more, current methods of producing animal meat are incredibly inefficient. Only 5 to 25% of the nutrients (depending on the animal) are converted into edible meat, according to Jason Matheny, a health economist at Johns Hopkins University in Baltimore, Maryland. The rest is spent on the animal's metabolism and on building inedible nerve and bone tissue.

Producing animal meat is incredibly inefficient. Only 5 to 25% of the nutrients are converted into meat

Fortunately, a remarkable alternative seems to be emerging: eliminate the animal from the production process entirely and instead grow the meat in a vat. "With in vitro meat there's no body to support," says Matheny. In vitro meat has been in development for decades, but only recently has it begun to be seen as a viable alternative to rearing livestock.

At the first In Vitro Meat Symposium, held at the Norwegian Food Research Institute near Oslo in April, Stig William Omholt of the Norwegian University of Life Sciences in Ås suggested that large-scale in vitro meat production could be implemented now for around 3400 euros a tonne, making it competitive with farm-raised meat, he says. In Europe unsubsidised chicken costs around 1800 euros a tonne, while beef costs just over 3500 euros.

In one scenario, the meat would be cultivated from muscle stem cells from cows, pigs and sheep. The cells are attached to either small edible spheres or a 3D scaffold and then cultured in a liquid nutrient broth until the clusters of muscle cells are large enough to harvest, says Bernard Roelen at Utrecht University in the Netherlands, who is developing technology to grow in vitro meat. The first "test tube" meats to hit the market are likely to be burgers, sausages, chicken nuggets and other minced meat products.

While in vitro meat won't be greenhouse-gas free, Matheny says emissions from the bioreactor plants would pale in comparison with those of conventional production. No methane emissions from the animals, no fertiliser production, no deforestation and pasture degradation. Matheny is crunching the numbers to see if in vitro meat can live up to its lean emissions promise.

2 Organic vs conventional

Though the organic label began as a mark of farming standards, for many people it has come to mean environmentally friendly, and often they assume that also implies lower CO2 emissions. Is that really the case?

Nathan Pelletier at Dalhousie University in Halifax, Nova Scotia, has compared the greenhouse gas emissions of organic and conventionally grown corn, wheat, soya and canola. He found that organically grown crops have a much smaller carbon footprint, consuming only 39% of the energy and producing only 77% of the greenhouse gases of their non-organic counterparts. The reason, says Pelletier, is eliminating nitrogen fertiliser from the cultivation process. Fertilisers account for roughly 1% of the world's total energy consumption.

However, the comparison is not so straightforward for all foods. For vegetable and fruit crops, it's almost impossible to compare organic with conventional without knowing exactly how or where the crop was grown. "It's very context-specific," says Pelletier.

Organic certainly doesn't always mean lower emissions. Organic poultry, for example, requires 10% more energy than battery-farmed poultry as the latter are raised in facilities where they can barely move so more of their food energy is converted into protein. Also, non-organic birds require less grain to make the same amount of meat, says Peter Melchett, policy director at the Soil Association, the UK's organic standards watchdog. An organically raised bird will need to live longer and eat more grain to reach the same weight.

Organic fish isn't that environmentally friendly either. For example, wild salmon is increasingly rare, so supermarkets offer organic and conventionally farmed salmon instead. Pelletier analysed the emissions from raising these two types of salmon and found that, contrary to popular belief, the organically farmed salmon were responsible for up to 30% more greenhouse emissions than conventionally farmed fish.

The reason is the salmon's diet. Fish feed is usually 50% grain and 50% fishmeal - a powder made from unsold fish and fish offal, or small whole fish. While using organically grown grain means a lower carbon tab than grain grown with synthetic fertilisers and pesticides, organic standards stipulate that the fishmeal component must come from fisheries certified as sustainable and for human consumption. Conventionally farmed salmon uses fishmeal derived from "reduction fisheries" that catch small oily fish like mackerel, herring and anchovy that travel in dense schools, which tend to be much more fuel-efficient to catch.

"You can get thousands of tonnes of fish in one scoop," says Pelletier. It typically takes less than 50 litres of gasoline to haul a tonne of these fish. Fisheries for human consumption are much more fuel-intensive - some run as high as 2000 litres per tonne. Using waste products from these fisheries to produce fishmeal sounds like a good idea - but actually has a much greater carbon trail.

3 Farmed vs wild fish

Tuna, cod and other deep-water fish all require fleets of fishing vessels scouring the seas in search of a catch. Since some of these fish can now be grown in fish farms, this would sound like a much less carbon-intensive means of production, since it all but eliminates fuel usage. Can it really produce lower greenhouse gas emissions?

No one has yet done a rigorous comparison of the various aquaculture schemes with industrial fishing, but Stuart Bunting, who specialises in aquatic resource management at the University of Essex in Colchester, UK, says that back-of-the-envelope calculations show where the major carbon emissions lie. One of the most carbon-intensive stages of fish farming is producing fishmeal, he says.

For cage-based costal salmon farming, which relies on currents and tides to remove waste, 90% of the greenhouse gases result from fishmeal production. Further energy is spent rearing the salmon smolts to a size where they can be released in the cages. In contrast, land-based closed containment requires less fishmeal, but instead consumes energy in keeping the fish tanks clean and at the right temperature, and so produces more greenhouse emissions overall.

One way to improve fish farming may be to look to traditional Chinese aquaculture, in which herbivorous and omnivorous species are reared in the same pond. This ecosystem-based approach allows plants to serve as food for animals higher up. This approach eliminates the need for greenhouse-gas-intensive fishmeal. Unfortunately, China's growing appetite for carnivorous fish is leading farmers to adopt western-style aquaculture, feeding the animals fishmeal and fish oil, at the expense of the traditional method's environmental benefits, says Bunting.

Farmed shrimp have a particularly large carbon wake. This industry has destroyed more than 30% of the world's coastal mangroves. Like rainforests, mangroves are carbon sinks. When they are drained and cleared they release both CO2 and methane.

What's more, it takes at least two kilos of fish and squid meal to produce a kilo of shrimp. That means not only a net protein loss, but a hefty carbon trail just to

produce these creatures' food. To make things worse, these shrimp are often flown to the west.

If you want to choose fish with a low carbon footprint Bunting and Pelletier recommend farmed herbivorous species - tilapia, carp, bream and catfish.

When it comes to wild seafood, "marine capture fisheries" - fishing fleets in the open ocean - are completely dependent on fossil fuels, as well as being susceptible to overfishing. They account for 1.2% of global oil consumption and emit more than 130 million tonnes of CO2 into the atmosphere per year. That is equivalent to the amount of oil used by the Netherlands, says Tyedmers, which is the 18th largest oil consumer on the planet. However, actual oil usage varies wildly depending on the type of catch. Small fish like herring and anchovy that travel in schools can be captured for 50 litres a tonne, whereas shrimp, tuna, swordfish, sole and flounder can require up to 40 times that.

4 Is local really green?

The local-food movement is touted as a major way to cut greenhouse emissions. The rationale is simple: buying locally grown food reduces the amount of fuel spent moving it from the farm to your dinner plate. That sounds logical, especially when you see how globalised the food supply can be; grapes from Chile, tomatoes from Mexico, and shrimp from India. Does this logic really stack up?

According to a study published in April in the journal by Christopher Weber, an environmental policy researcher at Carnegie Mellon University in Pittsburgh, Pennsylvania, transportation accounts for only 11% of food's total greenhouse emissions.

Weber calculated the CO2eq produced during the entire life cycle of various foods. He says that distribution from producer to consumer, better known as "food miles", accounts for just 4 per cent, while shipping produce from wholesalers to retailers and from retailers to consumers accounts for a mere 5% of a food's greenhouse emissions.

The majority of greenhouse gases, 83 per cent, come from the actual production of the food - 37% from CO2, 20 from methane released from livestock and manure, and 26% from nitrous oxide due to fertiliser and manure. Food miles only focus on CO2 emissions, says Weber, but once you add other gases like methane and nitrous oxide into the equation, the life cycle becomes a lot dirtier.

So for the average American, buying local every day of the year would cut their carbon foot print by only around 4% or 400 kg of CO2eq per year. By comparison, shifting just one day a week from eating red meat and dairy to either chicken, fish, eggs or vegetables lowers your emissions by between 252 kg and 400 kg of CO2eq.

Bijal Trivedi is a writer based in Washington DC

Online at: http://climatechange.flinders.edu.au/food&carbon.htm