Global Food Security 3 (2014) 67–71

Contents lists available at ScienceDirect

Global Food Security

journal homepage: www.elsevier.com/locate/gfs

Eating meat: Constants and changes☆

Vaclav Smil

University of Manitoba, Canada

ARTICLE INFO

Article history:
Received 5 June 2014
Accepted 19 June 2014

Keywords:
Carnivory
Meat production
Environmental impact
Environmentally sensitive production
Future meat consumption

ABSTRACT

Eating meat has been an important component of human evolution and rising meat consumption has made a major contribution to improved nutrition. Expanding the current practices of meat production would worsen its already considerable environmental consequences but more environmentally sensitive ways of meat production are possible. Although they could not match the current levels of meat supply, they could provide nutritionally adequate levels worldwide. This would mean a break with historical trends but such a shift is already underway in many affluent countries and demographic and economic factors are likely to strengthen it in decades ahead.

1. Introduction

Science is more than an impartial quest for a proper understanding of realities and for a better guidance through the complexities of modern decision-making: it is a social construct and hence not immune to being partial and getting deployed (sometime subtly, other time quite bluntly) in the service of various preferences and deeply-held opinions. Meat eating is a perfect example of what happens when advocacy and promotion of absolute stances displace impartial judgments of a complex reality. On one hand scientific evidence (excessively high environmental cost of meat, brutality of animal treatment and slaughter) is called on to support the case for meatless diets, on the other hand modern research-driven agriculture produces more feed crops than food crops to support record levels of meat production.

2. Carnivory and its consequences

There is absolutely no doubt that human evolution has been closely linked in many fundamental ways to the killing of animals and eating their meat. Our digestive tract is too short and too simple to serve an obligatory herbivore; enzymes it contains facilitate meat digestion; there is no need to invoke the expensive tissue hypothesis in order to affirm that meat consumption has aided higher human encephalization and better physical growth. Similarly, cooperative hunting of large animals helped to promote socialization and the development of language; and the history of sedentary Old World societies was closely linked with the domestication of animals and eating of their meat whose consumption was both a sign of higher social status and a source of dietary preferences and taboos. And modern science explained the consequences of protein deficiency, particularly in children, and it confirmed meat's nutritional advantages as an excellent source of all essential amino acids, lipids and important micronutrients.

We are, indubitably, an omnivorous species with a generally high degree of preferences for meat consumption, and only environmental constraints and cultural constructs of pre-industrial societies led to lower meat consumption, a shift that was reversed in all modern affluent societies. Higher meat consumption has been a key component of a worldwide dietary transition that was enabled by industrialization and urbanization, first in Europe and North America, in recent decades in modernizing economies of Asia and Latin America. Global meat production rose from less than 50 million tonnes (Mt) in 1950 to about 110 Mt in 1975; it doubled during the next 25 years, and by 2010 it was about 275 Mt, prorating to about 40 kg/capita, with the highest rates (US, Spain and Brazil) in excess of 100 kg/capita (all rates are for carcass weight).

But this has been a rather costly achievement because mass-scale meat production is one of the most environmentally burdensome activities, with impacts ranging from groundwater (contaminated with nitrogen leached from fields used to grow animal feed) to the global atmosphere (with CH_4 from enteric fermentation as a major contributor of a greenhouses gas with warming potential much higher than that of CO_2), and from soil erosion due

☆This essay summarizes some findings from my book *Should We Eat Meat? Evolution and Consequences of Modern Carnivory* (Wiley 2013) which contains detailed and extensively referenced accounts of feeding efficiencies, meat consumption rates, environmental burdens of meat production and potential meat substitutions. Detailed information on global food and feed harvests and on the availability of crop residues can be found in: Smil, V. 2013. *Harvesting the Biosphere: What We Have Taken from Nature* (MIT Press). One of the world's most notable dietary transitions whose outcome demonstrates the benefits of moderate meat consumption is surveyed in: Smil, V. and K. Kobayashi. 2011. *Japan's Dietary Transition and Its Impacts* (MIT Press).

http://dx.doi.org/10.1016/j.gfs.2014.06.001
2211-9124/

to tropical deforestation. Rising demand led to expanded traditional meat production in mixed farming operations (above all in the EU and China), to extensive conversion of tropical forests to new pastures (in Latin America) and to dominance of concentrated animal feeding facilities (for beef mostly in North America, for pork and chicken now worldwide except for Africa). This has created mass-scale feed industry based mainly on corn and soybeans (with added micronutrients and preventive doses of antibiotics), shortened production spans (just six to seven weeks for broilers, less than six months after weaning for pigs), and affected animal welfare.

There are at least five major categories of undeniable burdens created by modern mass-scale meat production that relies on concentrated animal feeding. The first one is a fundamental reorientation of traditional agricultures dominated by growing food crops to monocultures of animal feed with attendant increases in soil erosion, and intensified interference in water and nitrogen cycles. The second one is inherently inefficient conversion of phytomass to edible zoomass, particularly so in the case of ruminant meats, the most environmentally expensive food. The third one is generation of huge volumes of waste by centralized feeding operations that preclude near-complete nutrient recycling to crop fields. The fourth one are the emissions of greenhouse gases, both due to the cultivation of feed crops and to animal metabolism. And the fifth one is the treatment of animals in confinement (stressful conditions, impaired welfare) and some questionable ways of their slaughter.

Thinking about the road ahead we must recognize several fundamental realities. Solutions will not come from voluntary meatless diets, mass production of mock meat (transformed plant proteins) or muscle tissues cultured in bioreactors. Substituting meat intakes by consumption of other high-protein animal foodstuffs is of marginal help. At the same time, meat production based only on truly sustainable grazing, feeding of forages rotated with food crops, and maximum use of crop and processing residues is inherently limited and although, once it is reoriented toward producing less beef and more pork and chicken, it could supply a surprisingly large share of today's meat consumption (as I will show, close to 70% of 2010 supply) it will not be able to satisfy global demand anticipated for 2030 and even less so for 2050. Innovations and productivity improvements alone cannot prevent further increases in already significant environmental burden of meat production and to reduce them we will also need to moderate our meat consumption.

3. Meatless diets, mock and cultured meat

Commitment to vegetarianism (to say nothing about strict veganism) will not fundamentally affect future demand for meat. Insistent promotion of nutritional and environmental benefits of meatless diets has not had intended mass impacts. A much publicized anticipation illustrates the point: in 1975 in *The Book of Tofu*, Shurtleff and Aoyagi predicted that within 10–20 years the sources of America‘s dietary protein will be completely reversed, with 80% originating in plant foods, and that tofu shops will spread around the country, making an invaluable contribution to better life on our planet. But animal foods still supply about 65% of America's dietary protein, and small tofu shops have never sprouted in America, but have been rapidly disappearing even in Japan. Studies show that all forms of vegetarianism (ranging from those allowing consumption of dairy products and eggs to strict veganism) are practiced by no more than 2–4% of population in any Western society and that long-term (at least a decade) or lifelong adherence to solely plant-based diets has prevalence lower than 1%.

Moreover, there are no obvious population-wide advantages to vegetarianism. The world's longest living population is far from being vegetarian: Japan's per capita food supply now averages more than 50 g/day of animal protein, with about 40% coming from seafood and 30% from meat, and three of Europe‘s countries with the highest life expectancy – Sweden, Norway and Iceland – have diets with substantial quantities of meat and a large amount of dairy products. Voluntary population-wide abstention from eating meat is thus extremely unlikely and even if practiced it would have no significant health benefits compared to moderate consumption of meat and other animal foodstuffs.

Cultured meat will not be produced on a mass scale anytime soon and a long history of mock meat makes it unlikely that it will be anything but a marginal choice. An increasing array of vegetarian mock meats (shaped as burgers, patties, cutlets, nuggets, bacon, sausages etc., all basically reconstituted soy and wheat proteins and mushrooms) has been available for decades but the value of their recent US sales has been less than 0.2% of annual meat sales, hardly a promise of capturing a substantial market share in the near future. Promise of in vitro meat is also decades-old but recent reports of a near-perfect cultured hamburger make clear how challenging and how costly will be the process from experimental production of a few hundred grams to about 15 Mt/year that would be needed to capture just 5% of today's global meat market.

While veganism and mock and cultured meats will not prevent future rise of meat demand it is certain that global average per capita meat consumption will not rise to North American or the EU levels, and there is actually a high probability that the current consumption rates in affluent countries will decline. Long-term models are notoriously error-prone: think about a 30-year forecast of any consumption variable done in 1980 for China (four years after Mao's death) or the USSR (11 years before its collapse). What is much more useful than offering forecasts based on economic growth or anticipated consumption patterns is to estimate how much meat could be produced with minimized environmental impact and in a truly sustainable way.

The baseline quantity would be produced without any cultivation of feed grains (cereal and legume) only by combining available crop and processing residues with more environmentally-sensitive use of pastures. The next step is to ascertain what share of the current meat output could be replaced by non-meat animal protein produced with lower environmental burden. Obviously, these calculations are just the best approximations of relevant global totals but because my assumptions consistently err on a conservative side they provide a revealing reality check on what is possible.

4. Grazing, crop and processing residues, and forages

Most of the world's grasslands have been already degraded by overgrazing and that is why I assume that the pasture-based meat production should be reduced by an average of 25% in all low-income countries and by at least 10% in affluent countries, and that in order to prevent further deforestation and loss of biodiversity there should be absolutely no additional conversion of forests to grasslands in Latin America, Africa and Asia. These measures would reduce pasture-based global beef output to about 30 Mt/year (compared to more than 50 Mt in 2010) and mutton and goat meat production to about 5 Mt (compared to more than 10 Mt in 2010). An alternative way to calculate the maximum safe grazing contribution is to assume 25% of all currently grazed area should be set aside to recuperate and the remainder (2.5 billion ha) should support no more than about half a livestock unit (LU, about 250 kg of live weight; EU limit is 1 LU/ha, Brazilian pastures support 1 LU/ha, 0.5 LU/ha is common in sub-Saharan Africa). With average