V

The Impact of the Agricultural Revolution on Food: The Cardiac Consequences

Felix qui potuit rerum cognoscere causas.[1]

Fats: Saturated and Unsaturated

It is obviously impossible to measure directly the impact of the eighteenth-century changes in English farming practices on the fat content and fatty acid characteristics of the animals that were then raised for human consumption. The necessary analytic techniques had yet to be developed. However, some cautious deductions can be made from studies during the last century. As detailed in Chapter IV, the food available to animals and birds farmed in England before the Agricultural Revolution, or more currently in developing societies, was not very different from that of free living herbivorous birds and animals. It is probable therefore that some 300 and more years ago the fat composition of English domestic animals and birds corresponded roughly to that of their twentieth-century descendants, either foraging in the wild or herded in developing societies where animal husbandry has been unaffected by the Agricultural Revolution. The fat characteristics of these last two categories have been studied,[2] as have the lipid profiles of domestic animals and birds farmed in developed societies in the mid-twentieth century.[3] This was before consumption of animal fat was considered to be a potential health hazard and western world farming practices began to be modified in order deliberately to produce leaner cattle, sheep, pigs and poultry. It follows that comparisons drawn from all of these sources should give some measure of the differences between the pre- and post-Agricultural Revolution on the status of English farm animals with respect to total carcass fat as a percentage of total weight, the amount of fat in muscle and its fatty acid composition.

In general, it can be said that until the middle of the last century domesticated

[1] Virgil, *Georgics*, 2.490.

[2] M A Crawford, 'Fatty-acid ratios in free-living and domestic animals. Possible implications for atheroma', *Lancet*, 1968, i: 1329–33, pp. 1331–2; H P Ledger, 'Body composition as a basis for comparative study of some East African mammals', in M A Crawford (ed.), *Comparative nutrition of wild animals: the proceedings of a symposium held at the Zoological Society of London held on 10 and 11 November 1966*, London, published for the Zoological Society of London by Academic Press, 1968, pp. 289–310, pp. 306–7.

[3] Andrew J Sinclair, W J Slattery and K J O'Dea, 'The analysis of polyunsaturated fatty acids in meat by capillary gas-liquid chromatography', *J Sci Food Agric*, 1982, **33**: 771–6, p. 772.

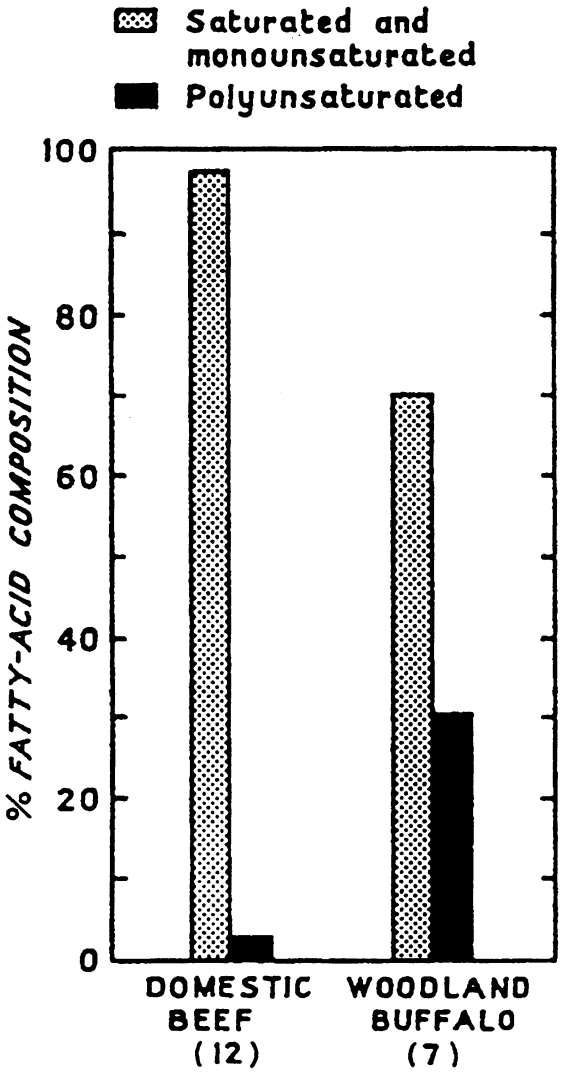

Figure V.1: Fatty acid composition of free living woodland buffalo and domestic beef compared. Number of animals in brackets. Reproduced from M A Crawford, 'Fatty-acid ratios in free living and domestic animals. Possible implications for atheroma', *Lancet*, 1968, i: 1329–33, p. 1331. (Permission granted by The *Lancet* Ltd.)

animals and birds in the developed world were far more adipose than their twentieth-century counterparts that either grazed in the wild (Figure V.1) or were reared in developing countries. Evidence cited earlier (pages 50, 53) indicated that the increase in weight of domestic animals subsequent to the introduction of late-eighteenth-century feeding techniques consisted largely of fat. In the mid-nineteenth century Lawes and Gilbert estimated the percentage of fat in the carcasses of a number of

animals that either received the usual feed for that period or had been specially fattened as part of an investigation. The percentage of carcass fat in a "store", i.e. standard fed pig, and a "store" fed sheep were 28.1 and 23.8 per cent respectively. Among eight specially fattened sheep, cattle and pigs the average fat percentage was 36.5 per cent.[4] H P Ledger found that the fat content of four ranch-fed zebu, an East African variety of cow, was 32.9 $\pm$ 3.3 per cent. In contrast, he found that in a group of nine zebu that had been herded in traditional ways, the fat constituted a mean of only 13.4 $\pm$ 5.9 per cent of total carcass weight.[5] Contemporary studies have shown too that the fat content of poultry can be increased by over 50 per cent in any one strain by appropriate changes in the feed provided.[6]

The fat contribution to total carcass weight is not confined to obviously visible deposits. Numerous studies have shown that the fat content of the muscle, i.e. the apparently lean meat, can contain fat in varying quantities depending on feeding practices. As examples, Australian studies showed the fat content of pork leg to be almost 50 per cent greater than in corresponding tissues obtained from wild pigs. The muscle content of pastured beef was four times that of buffalo and that of lamb over five times the fat content of free ranging deer.[7] M A Crawford found even more extreme differences; the fat content of wild bovid never exceeded 3 per cent; domestic meat fat ranged from 3 to 18 per cent.[8]

The fat of pastured animals and birds is not only greater in amount than that of their free ranging cousins. There are significant qualitative differences as well. The proportion of polyunsaturated fatty acids (PUFA) is higher and that of saturated and monounsaturated fatty acids (SFA and MUFA) lower in free living animals and birds when compared with those raised on farms. A study of wild buffalo and warthogs showed that the percentage of polyunsaturated fatty acids were 30 and 44 per cent respectively. In contrast, the PUFA percentages of fat-tailed sheep and samples of pork and beef obtained from slaughterhouses were very much lower, 4, 8 and 2 per cent respectively (Table V.1). These differences in fat composition have even been found when closely related species were compared.[9] The PUFA also form a significantly greater proportion of total fat among birds reared in the wild. Forty per cent of wild grouse fat was found to be polyunsaturated whilst among domestic chickens this percentage was 17. Similar chemical differences have been found in a comparison of the fat composition of wild and farmed pigs.

Although polyunsaturated fat as a proportion of the total lipid content was higher among wild animals, the absolute amounts were, weight for weight, less than in those that were pastured. The polyunsaturated fatty acids constituted a higher

[4] J B Lawes and J H Gilbert, 'Experimental inquiry into the composition of some of the animals fed and slaughtered as human food', *Philos Trans Roy Soc*, London, 1859, **149**: 493–680, p. 520.

[5] Ledger, op. cit., note 2 above, pp. 306–7.

[6] G Havenstein, personal communication, quoted by Peter Hunton, 'The broiler industry. Thirty-four years of progress', *Poultry International*, 1995, **34**: 28–30, p. 28.

[7] Sinclair, Slattery, O'Dea, op. cit., note 3 above, p. 772; A J Sinclair and K J O'Dea, 'The lipid levels and fatty composition of the lean portions of pork, chicken and rabbit meats', *Food Technol*, Australia, 1987, **39**: 232–3, 240.

[8] M A Crawford *et al.*, 'Comparative studies on fatty acid composition of wild and domesticated meats', *Int J Biochem*, 1970, **1**: 295–305, p. 302.

[9] Crawford, 'Fatty-acid ratios', op. cit., note 2 above, p. 1331.

Table V.1
Fatty acid composition of muscle as percentages: wild and farmed animals and birds

	SFA and MUFA combined	PUFA
Wild Buffalo	71	30
Pastured Beef	99	2
Wild Pig Leg	71	28
Pork (farmed pig)	92	8
Fat-tailed Sheep	96	4
Wild Giraffe	61	39
Captive Giraffe	96	4
Wild Grouse	60	40
Domestic Chickens	83	17

Source: M A Crawford, 'Fatty-acid ratios in free living and domestic animals. Possible implications for atheroma', *Lancet*, 1968, i: 1329–33. (Permission granted by The *Lancet* Ltd.)

proportion of a much lower total carcass fat content. The differences in the chemical composition of fat that have been described appear to be general. They have even been found when wild and captive giraffes were compared, the former having a higher PUFA percentage than the latter. Of possible significance, the polyunsaturated fat of wild animals is predominantly phospholipid. In twentieth-century farm animals it is mainly triglyceride.[10]

Crawford and his colleagues found too that the fat of free living animals contained significant amounts of long chain (C20-5 N3 and C20-6 N3) polyunsaturated fatty acids. These were scarcely detectable in the fat of domesticated animals.[11] This is of possible significance in view of the mildly inhibitory action on human blood coagulation and clotting detected in similar long chain fatty acids derived from fatty fish and marine mammal oils.[12]

The results obtained in the wild animals and the example cited from a developing society give an approximate indication of what would have been the fat content and characteristics of animals reared before the English eighteenth-century changes in animal husbandry, i.e. low in the amount of total fat and with the PUFA proportion high. In contrast, the lipid content of domesticated animals reared in mid-twentieth-century developed societies provides some indication of what would have been the fat content and characteristics of animals farmed in England after the eighteenth-century agricultural changes, high in total fat content and with the PUFA proportion low and probably different qualitatively.

As observed in the previous chapter, there is evidence to suggest that with the better feeding techniques some breeds of pig did increase in weight. Twentieth-century studies show that saturated fatty acids predominate over unsaturated in the

[10] Crawford *et al.*, op. cit., note 8 above, p. 299.
[11] Ibid., p. 300.
[12] Clemens von Schacky and Peter C Weber, 'Metabolism and effects on platelet function of the purified eicosapentaenoic and docosahexaenoic acids in humans', *J Clin Invest*, 1985, **76**: 2446–50, pp. 2447–8.

adipose tissue of pigs reared in the developed world. As they are not ruminants, their body lipid composition tends to reflect closely that of the fats in their diet. As dairy products (now known to be high in saturated fat content) were increasingly used for feed during the course of the eighteenth century, it is likely that porcine fats were consequently high in SFA at that time too.[13]

As noted earlier, poultry production rose during the early eighteenth century and the increase continued thereafter. Twentieth-century studies have shown that egg yolk characteristics are subject to variations in response to the type of feed provided. Thus a study of 18 differing genetic lines of experimental chickens showed that mean yolk weights in each line could vary from a low of 14.55 g to a high of 18.71 g and the cholesterol content, expressed as mg/g yolk, from a low of 13.30 to a high of 15.58.[14] Changes in feeding techniques, including addition of cholesterol to the feed, could increase yolk weight by up to 3.29 g in any one strain and yolk cholesterol content by up to 2.01 mg/g. Although there was a tendency for heavier yolks to be associated with somewhat lower cholesterol concentrations, the overall effect was for the larger yolks to contain greater absolute amounts of cholesterol. The latter also responds positively to cholesterol in the hens' diet and to their total energy intake.[15] The changes that can result from improved feeding methods can be gauged by comparing the yolk cholesterol content of currently domesticated birds with that of their cousins in the wild. In one typical study, the egg yolks of domestically raised turkeys and ducks were found to have a mean cholesterol content almost 2 mg greater than that of free ranging birds.[16] These twentieth-century differences give some indication of the possible impact of eighteenth-century changes in poultry management on the cholesterol content of eggs. Probably much more important than the chemical characteristics of individual yolks was the impact of eighteenth-century farming improvements on the number and continuous availability of eggs. The rate of increase in the number of laying fowl during the early eighteenth century probably exceeded the rate of human population increase in England and Wales at that time.[17] Productivity of the individual birds became greater, notwithstanding an unavoidable fall in the number of eggs laid during winter with its reduced hours of sunlight and the absence then of effective forms of artificial lighting. In so far as conclusions can be drawn from twentieth-century studies, the data reported raise the possibility that eighteenth-century changes in poultry management resulted in greater availability of eggs with higher average SFA and cholesterol contents and a consequent increase in atherogenic potential.

In conclusion, the data presented suggest that English farmed animals were a

[13] Peter W Bowden, 'Agricultural prices, wages, farm profits, and rents', in Joan Thirsk (ed.), *The agrarian history of England and Wales, Volume V: 1640–1750. II. Agrarian change*, Cambridge University Press, 1985, p. 32.

[14] Craig W Bair and William M Marion, 'Yolk cholesterol in eggs from various species', *Poult Sci*, 1978, **57**: 1260–5, p. 1264.

[15] P Stewart Hargis, 'Modifying egg yolk cholesterol in the domestic fowl', *World Poult Sci J*, 1988, **44**: 17–29, p. 19.

[16] Bair and Marion, op. cit., note 14 above, p. 1261.

[17] E Anthony Wrigley *et al.*, *English population history from family reconstitution 1580–1837*, Cambridge University Press, 1997, p. 614.

Table V.2
Effect of varying PUFA as percentage of constant total fat intake. Lipid profile at beginning and end of trial

PUFA %	LDL Cholesterol (mmol/L)		VLDL Cholesterol (mmol/L)		Apo B (mg/L)		HDL/Total	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
3	2.07±0.08	2.33±0.59*	0.22±0.05	0.27±0.12	664±202	718±175	0.36±0.06	0.35±0.05
19	1.91±0.40	1.98±0.60	0.27±0.13	0.23±0.12	580±103	574±120*	0.35±0.06	0.38±0.06

* P<0.05: change from initial values.

Source: Jantine A Brussaard *et al.*, 'Effects of amount and type of dietary fat on serum lipids, lipoproteins and apolipoproteins in man. A controlled 8-week trial', *Atherosclerosis*, 1980, **36**: 515–27, 515. (With permission from Elsevier Science.)

scant source of fats prior to the Agricultural Revolution, but the changes that it brought about resulted in a very great increase in the availability of the animal fats associated with meat, poultry, eggs and dairy produce. There is indirect evidence to suggest that there was an accompanying increase in predominance of saturated as opposed to unsaturated fatty acids. It remains to consider the consequences.

Dietary Fats and Coronary Heart Disease

In the present study it is thought adequate for the most part to provide evidence for a considerable eighteenth-century increase in the availability of animal fats in general and saturated fats in particular. It is not considered necessary to marshall in any more than summary form the now well-established reasons for associating high animal fat intake with a lipid profile conducive to development of coronary heart disease. Reference to a limited number of late-twentieth-century landmark studies should suffice.

A direct relationship between high saturated animal fat consumption and raised serum cholesterol levels has long been established, dietary changes altering the lipid profile significantly in little over a month. For example, as part of a wider study, Jantine H Brussaard and his colleagues studied forty healthy young subjects of both sexes. Following a run-in period on identical diets, two groups took 40 per cent of their energy requirements as fat. For one-half of the subjects, 3 per cent of the fats were polyunsaturated. Saturated and monounsaturated animal fats constituted the remainder. For the second group, the polyunsaturated fats, mainly of vegetable origin, were raised to 19 per cent and the saturated animal fats correspondingly reduced. Initially the lipid profiles of the two groups were almost identical. After five weeks the mean serum total cholesterol, triglycerides, apolipoprotein-B and low density lipoprotein (LDL) cholesterol levels were all significantly higher in the group with the higher saturated fat intake. The HDL/cholesterol ratios were minimally lower (Table V.2).[18] *Mann ist was mann isst.* The Seven Countries Investigation

[18] Jantine H Brussaard *et al.*, 'Effects of amount and type of dietary fat on serum lipids, lipoproteins and apolipoproteins in man. A controlled 8-week trial', *Atherosclerosis*, 1980, **36**: 515–27, pp. 520–3.