THE CHEMICAL COMPOSITION OF MEAT FROM WILD AND DOMESTICATED ANIMALS

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INTRODUCTION

Mammals used as meat for humans are considered. Because the animo acid composition of their muscle protein (meat) is remarkably similar despite a wide variation in food from grass to meat (Crawford, 1973), differences in the amount and composition of their fats will be the theme of this paper.

Fat has much to do with the acceptance of meat. Apart from its visual impact it is largely responsible for the characteristic flavour of cooked meat. Fat contains polyunsaturated fatty acids essential for the synthesis of prostaglandins and vital tissues such as brain and nerve. Fat also affects the cardio-vascular system, whether for better or worse, depending on its chemical composition.

TERMS

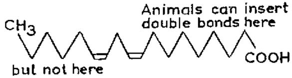
Meat fat may be divided into two classes—visible fat which is mainly triglyceride, and invisible fat which is high in phospholipid. Triglycerides are esters of glycerol with fatty acids such as palmitic, stearic, linoleic and linolenic. Palmitic acid contains 16 carbon atoms and the rest 18.

Phospholipids are also esters of glycerol but with only two fatty acids. A terminal carbon is joined to phosphoric acid which in turn is connected to a base such as choline, serine or ethanolamine.

Fatty acids have the general formula R.COOH and most that occur in nature contain an even number of carbon atoms. R is an alkyl group in the saturated fatty acids, the most important in nutrition being palmitic and stearic. The removal of two adjacent hydrogens with the formation of a double bond in the alkyl chain yields a mono-unsaturated acid, the best known being oleic. From the nutritional point of view, the saturated and mono-unsaturated fatty acids function in a similar manner, and the animal is able to synthesize them. It cannot synthesize certain polyunsaturated acids such as linoleic with two double bonds or linolenic with three double bonds. Linoleic and linolenic acids must be obtained from plants which can synthesize them or from animal material containing these acids of plant origin. Leaves and grass are rich in linolenic acid, seeds in linoleic, while bark contains both. Because linoleic and linolenic acids are necessary tissue components and precursors of other important compounds, they are called essential fatty acids and in some ways resemble vitamins.

An animal can insert double bonds between a carboxyl group (COOH) and the nearest double bond but not between the terminal methyl group (CH_3) and its nearest double bond.

LINOLEIC ACID



Thus the insertion of two double bonds and two carbon atoms yields

ARACHIDONIC ACID

Similarly, linolenic acid may be changed to polyunsaturated fatty acids with 20 or 22 carbons by chain lengthening and desaturation. Arachidonic acid is primarily incorporated into structural lipids (*e.g.*, phospholipids), whereas linoleic acid is mainly found in storage lipids (triglycerides).

VARIATIONS BETWEEN ANIMALS IN CARCASS COMPOSITION

In comparing the meat of wild and domesticated animals, three factors should be considered—the percentage of meat or carcass muscle, the percentages of the major components of the meat, and the composition of their fats. Not surprisingly, wild animals, including many ungulates, tend to have higher percentages of meat, partly because they have little fat. For example, kangaroos have 52% carcass muscle, sheep 27%, cattle 32% and pigs 32% (Frith and Calaby, 1969).

MEAT COMPOSITION

Water is the major component of meat, usually present in the range 65 to 75%, but the amount of fat varies greatly. The chemical composition of bovine skeletal muscle is approximately 73% water, 17 to 21% protein, 10 to 20% fat, and 1% phospholipids (Sinclair, 1973). Nutritionally, protein is the most

TABLE 1: FAT CONTENT AND COMPARISON OF VARIOUS MEATS

Sample	*Percentage Fat*	*Ratio of Polyunsaturated to Saturated and Mono-unsaturated Fats*
Cattle (lean steak)[1]	9.4	0.043
Lamb (chop)[1]	3.5	0.087
Horse (steak)*[2]	2.7	1.0
Buffalo (steak)[1]	2.1	0.55
Eland (steak)[1]	2.0	0.66
Deer (chop)[1]	1.6	1.18
Calf (cutlet)[1]	1.2	0.59
Kangaroo (steak)*[2]	1.2	1.0
Chicken (breast)*[1]	0.9	0.59

*Non-ruminant.

[1]Sinclair, 1973. [2]Redgrave and Vickery, 1973.

important part of meat and visible fat is largely undesirable. The meat of wild animals such as deer is low in fat and, as much of this fat is part of the muscle wall, it is called structural fat. However, the meat of domestic animals such as sheep and cattle contains visible, storage fat which is highly saturated and invisible fat which is a mixture of storage and structural fat. Table 1 shows the fat contents of meats of various animals.

With meat from domestic cattle (25% fat), for every kilogram of protein, 2.3 kg of saturated and mono-unsaturated fat will be consumed. But with meat from wild cattle (5% fat), for every kilogram of protein, 0.3 kg of largely polyunsaturated fat will be consumed (Crawford *et al.*, 1970).

These differences are due to the species of animal, its feed and its living habits. For example, deer put on only one half to one third as much fat as sheep given identical food and treatment; on poor, restricted rations or on very rich, *ad lib.* rations, they are much leaner. Wild deer are not necessarily lean because they are underfed. This is probably associated with their higher metabolic rate (about 10 to 20% higher than sheep on a $W^{0.75}$ basis, fed or fasted) and their higher maintenance requirement (about 30% higher than sheep on a $W^{0.75}$ basis) since protein is more costly to maintain than fat (R. Kay, pers. comm., 1973).

FAT COMPOSITION

Effect of Animal Species

In comparing meat fats two factors are important and interrelated—the percentage of fat present and the relative amounts of polyunsaturated and mono-unsaturated/saturated fats.

The greater the fat content, the lower will be the polyunsaturated proportion (Crawford *et al.*, 1970). It is probable that the high amount of saturated and mono-unsaturated fatty acids in the high fat state represents a fat infiltration, predominantly triglyceride. Table 1 supports this relationship. A high ratio, as shown by deer, horse and kangaroo, might be regarded as indicating that their fat is most nutritionally desirable.

Effect of Diet

In Table 2 it can be seen that, when buffalo, topi and giraffe move from a woodland environment to a park or grassland, the proportion of polyunsaturated fat decreases. The greater polyunsaturated fat of the woodland ruminant is due to his eating a diet richer in polyunsaturated fats and because some of his food such as seeds passes through the rumen unaffected by its hydrogenating enzymes.

TABLE 2: CHANGE IN PROPORTION OF POLYUNSATURATED MEAT FAT ON DIFFERENT FEEDS
(Crawford, 1968)

Animal and Environment	*Ratio of Polyunsaturated to Saturated and Mono-unsaturated Fats*
Park buffalo	0.11
Woodland buffalo	0.43
Grassland topi	0.087
Woodland topi	0.30
Zoo giraffe	0.042
Woodland giraffe	0.64

Animals on grassland diets may develop vascular diseases. Thirteen elephants living in a degenerate grassland had a high incidence of atheroma and calcium deposits in the aorta whereas there was less in 18 elephants from a scrubland habitat and negligible amounts from 9 elephants in a woodland habitat (Crawford, 1968). Other workers have confirmed the high incidence of atheroma in grassland elephants and also comment on its analogy with human atheroma (see Crawford, 1968).

At this stage one might conclude that the meat from deer, kangaroo, horse and eland is nutritionally superior to that of sheep and cattle.

Fatty Acid Composition

The percentages of the major saturated (palmitic, stearic), mono-unsaturated (oleic), and polyunsaturated (linoleic, linolenic and arachidonic) fatty acids demonstrate the marked differences in the muscle fat of various animals (Table 3). Of the ruminants

TABLE 3: PERCENTAGES OF FATTY ACIDS IN MUSCLES OF VARIOUS ANIMALS

	16:0	18:0	18:1	18:2	18:3	20:4
Animal	*Palmitic*	*Stearic*	*Oleic*	*Linoleic*	*Linolenic*	*Arachidonic*
Cattle[3]	28.6	7.9	46.2	0.7	1.1	1.5[2]
Lamb[3]	24.4	26.5	36.8	2.0	2.8	ND
Human*[1]	20	8	50	6	0.5	0.5
Pig*[3]	28.0	18.3	40.2	7.4	0.9	0.3
Eland[2]	20.0	19.0	17.0	19.0	3.3	6.6
Horse*[4]	22.5	12.9	21.6	19.9	10.1	5.0[5]
Kangaroo*[4]	15.2	16.4	29.3	21.5	7.3	7.2
Grouse*[3]	16.7	5.7	10.7	31.9	30.3	ND

*Non-ruminant. ND—Not determined.

[1]Crawford, 1968. [2]Crawford *et al.*, 1970. [3]Hubbard and Pocklington, 1968. [4]Redgrave and Vickery, 1973. [5]Payne, 1971.

the eland has the most polyunsaturated fat. It has been successfully domesticated by the Russians and moreover supplies appreciable quantities of milk. On grass the amounts of its polyunsaturated fatty acids would decrease. It should be remembered that the meat of animals with high levels of fat contains infiltrated storage fat as well as structural fat. The structural fat is mainly phospholipid whose fatty acid composition does not change a great deal. The polyunsaturated fatty acids in the ethanolamine phosphoglycerides of cattle and buffalo muscle are similar (Sinclair, 1973).

Table 4 shows how the percentages of polyunsaturated fatty acids of several ungulates vary according to feed and location of the fat, whether subcutaneous or muscle fat. The differences are striking.

TABLE 4: PERCENTAGES OF POLYUNSATURATED FATTY ACIDS IN FATS OF VARIOUS UNGULATES
(Crawford *et al.*, 1970)

	Fatty Acids			
Animal	*18:2*	*18:3*	*20:4 20:5*	*22:5 22:6*
Woodland buffalo muscle	16.0	5.0	8.2	3.2
Grassland buffalo muscle	8.5	2.3	4.4	2.6
Wild giraffe muscle	28.0	3.4	10.5	5.0
Wild giraffe subcutaneous fat	4.2	2.8	0.3	—
Zoo giraffe muscle	5.0	0.3	1.4	1.0
Ox lean meat	6.4	1.0	1.5	0.8
Ox whole meat	2.1	0.8	0.7	0.8
Ox adipose tissue	0.8	0.2	—	—
Eland muscle	19.0	3.3	6.6	4.0
Eland subcutaneous fat	4.0	3.0	1.1	1.0
Hartebeest muscle	21.0	6.0	3.6	3.2
Hartebeest subcutaneous fat	3.0	2.0	0.4	0.9

CONCLUSION

Because free-living animals in woodland had greater proportions of polyunsaturated fatty acids (30%) in muscle tissues compared with the same species on parkland or grassland (10%), and because wild species in captivity fed on hay had low proportions of polyunsaturated fatty acids similar to those of domestic animals, led Crawford (1968) to suggest that the primary reason for the difference is dietary.

Diet is very important but so is the species of animal. At Invermay the opportunity exists to compare the muscle fat of deer in the wild state, on grass and in a feedlot. Even if their meat fat composition is similar to that of sheep and cattle, the very low amount of fat present makes the meat nutritionally more acceptable.

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