Venison in the human diet - is venison a low-fat meat?

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Summary

Venison is promoted as a low-fat meat. This is true, provided that husbandry systems are used which take account of the effects of age, liveweight and season on carcase fat content. Deer generally have little carcase fat, and almost no subcutaneous fat, during their first year. Carcase fat contents in adult animals, particularly males, increase with liveweight which may be a function of age and/or feeding regime. Adult males have seasonal reproductive cycles and lose liveweight, and especially fat, during the rut. Venison lean tissue is relatively rich in polyunsaturated fatty acids and has a moderate cholesterol content. Deer farming systems should be designed to optimise the nutritional quality of venison as well as production efficiency.

Introduction

The Australian deer industry is based on farmed red (*Cervus elaphus*), fallow (*Dama dama*) and rusa (*C. timorensis*) deer. Its main products are deer meat (venison) and velvet (immature antler).

Meat, including venison, is used in the human diet as a source of protein (amino acids) and other nutrients, and for its taste, texture and aroma. Attributes of venison, such as its yield and quality, organoleptic properties, and mineral and amino acid contents, etc have been dealt with elsewhere (1-6). Fennessy and Drew (7) and others have discussed the effects of farming practices on venison production and quality.

Venison is promoted as a low-fat meat (8, 9), but this view probably derives from the qualities of game venison. Most of the commercial venison eaten in Australia is from farmed animals, and this may be fatter (10-12) than game venison. Fat content is an important aspect of meat quality because it confers juiciness, texture and taste, and aids cooking. However, above a certain threshold, fat in meat is discriminated against. It confers unwelcomed properties on meat if the melting point is too high (ie the fat is too saturated), or if it contains unpleasant off-tastes which may be incorporated from the animal's food or result from its metabolism. In nutritional terms, meat fat is often seen as being simply a source of energy, which as Drew (3) has pointed out, is not now considered as desirable a nutrient in the human diet as it may once have been. Meat fat is considered to be a source of saturated fatty acids and cholesterol, and thus unhealthy.

These questions of the fat content and fatty acid composition of venison need to be reassessed. This review will consider recent information on both these aspects.

Deer can produce a high-yielding, lean, low-fat meat

Deer have a high ratio of carcase weight to live animal weight, eg 56 to 63% in rusa deer (13), 55 to 57% in red deer (3, 14), 55 to 61% in fallow deer (2, 15). This may reflect their ecological classification as concentrate selectors and mixed feeders (16), as the digestive tract is a smaller proportion of the total body weight in this type of animal.

The proportions of lean tissue, fat and bone in deer carcases illustrate the generally low-fat nature of venison and its high lean meat content (Table 1). The yield of protein-rich (lean) tissue is generally higher in deer than in conventional meat animals. Deer have higher lean : bone ratios than cattle - eg more than 5 : 1 in red deer (3), 5.5 : 1 in fallow deer (17), up to 4.7 : 1 in rusa (18), compared to 4.4 : 1 for bulls (3).

Table 1. Carcase tissue

Description		Carcase weight (kg)	Proportion of carcase (%) Lean	Bone	Fat	Reference
rusa						18
13 months,	males	38	75.9	18.9	5.2	
19 months,	males	54	75.6	17.0	7.4	
25 months,	males	57	74.5	15.8	9.6	
red						
22 months,	males	59			3.2	14
2-4 years,	pre- rut	94[1]	69.0	12.1	19.0	19
2-4 years,	post-rut	78[1]	80.8	14.7	5.2	19
pre-rut,	males	120	66.0	12.9	20.8	3
post-rut,	males	87	83.2	15.5	1.3	3
1-5 years,	females	22-55	70.2	18.8	6.5	20
fallow						
13- 25 months,males		25-36	73.9	13.6	9.1	17

[1] calculated from liveweights, assuming 55% dressing percentage

Low fat contents have been reported in Japanese sika deer (*C. nippon*), which had 66 to 79% lean, 18 to 20% protein and 2 to 3% fat (21), and in farm-reared Australian chital (*Axis axis*) which had 2.2 to 7.2% fat (22). New Caledonian workers (23) have reported 0.7% fat in the carcases of 2-yr-old Javan rusa (*C. t. russa*) stags. For comparison, ram lamb and bull carcases may have between 18 to 27% fat at slaughter weight (3).

Notwithstanding its low-fat reputation, venison can sometimes have a comparatively high fat content. Drew (12) cites data for a variety of deer species farmed in New Zealand (fallow; red; wapiti, *C. canadensis*) in which carcase composition varied between 61 and 76% lean, 14 and 23.5% bone (fallow least, wapiti most), and 4 and 20% fat (both extremes were from red x wapiti hybrids).

Venison production systems must optimise not only production efficiency, but also venison quality. Some of the factors which influence fatness in deer are discussed below.

Age, sex, season and nutrition influence fat in venison

Age

Deer grow fairly uniformly throughout their first year and then show seasonal variations, as is illustrated by growth of entire (ie uncastrated) Javan rusa males at the University of Queensland, Gatton College (Figure 1). Young deer, up to a year old, had little subcutaneous fat; males aged 13 months had practically no subcutaneous fat at the loin, and only a thin layer at the rump.

Fat in males increases with age. Gregson and Purchas (17) reported 4 to 9% dissectable fat in yearling fallow deer, and 9 to 15% in 2 year-olds (both comparisons were made in summer). There are similar data for farmed red deer (3, 12) and rusa deer (13). Increased fatness in older animals can lead to problems of carcase quality. Trim and kidney fat increased to 13% of the carcase weight in fallow deer aged 4 years (2), and others (24) have noted that heavy fallow males can have an unacceptable amount of fat.

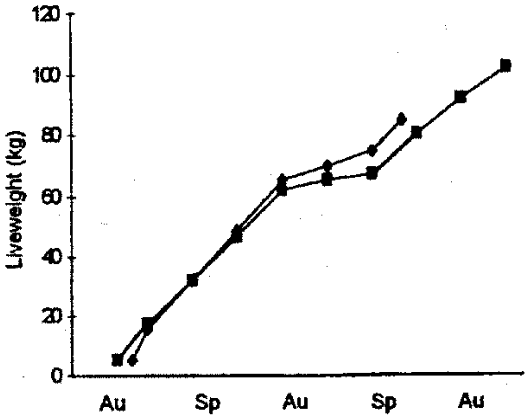

Figure 1 Growth in two groups of Javan rusa males from birth to 19 or 25 months (13)

Season and sex

In all deer species, seasonal changes in fatness are related to the animal's reproductive cycle, which is entrained by melatonin production in response to changing daylength (25). Males of temperate species, such as the red and fallow, become sexually active (rut) in late summer/autumn. Food intake by male red deer is greatest in summer, and least in autumn/winter (26, 27). Red stags may not eat at all during the rut. Pre- and post-rut comparisons in farmed red stags (19, 28) show that carcase fat stores are markedly reduced following rutting. These authors reported that depot fat declined from 18% to 4% of carcase weight, and recorded decreases in subcutaneous (reduction of 80%) and intramuscular fat. Drew and Suttie (29) found, in red stags aged six years, that carcase fat rose from 2 to 3% in winter to about 23% at the end of the summer. Similar patterns of fat accretion have been reported in European fallow and roe (Capreolus capreolus) deer (10, 30).

Tropical deer species may have no closely defined reproductive season; the chital, *Axis axis* (22) and the Moluccan rusa, *C. t. moluccensis* (31) are examples. Seasonal changes in fat cover in chital deer are slight, although carcase fat content is least in summer (22). In contrast to some other tropical species, the sexual activity of Javan rusa males is concentrated into July/August. Ultrasound measurements of subcutaneous fat in 2-year-old Javan rusa males (13) indicated a seasonal pattern of fat cover similar to the chital (Figure 2), except that fat thickness

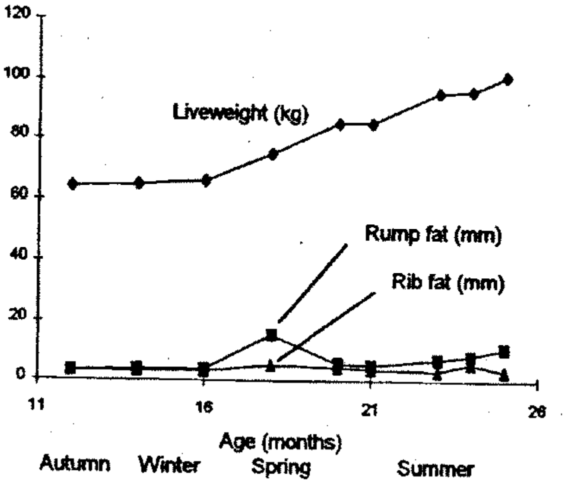

Figure 2 Liveweight and subcutaneous fat thickness in Javan rusa males, from 12 to 25 months (13)

was also low in winter. Rump fat thickness in July was 3.7 mm, 15.1 mm in September, then fell to 5.1 mm in December and rose to 10.1 mm in April. These seasonal changes in fat cover paralleled changes in food intake, although the amplitude of food intake changes in these rusa stags was less than those which have been reported in male red deer (eg 32).

Castration of males has been recommended as a way of making stags more tractable. It seems to have little effect on carcase fatness, although tendencies towards increased fatness have been reported in castrates (13, 15), especially after the rut (13).

Nutritional status

Low-energy diets (7.7 v. 12.7 MJ digestible energy/kg) fed to two-year-old female white-tailed (*Odocoileus virginianus*) deer (33) produced pronounced (about 50%) reductions in fat indices (eg kidney fat index, femur marrow fat content). Liveweight (but not carcase weight) was affected by diet protein content (7.5 v. 17%). Feeding a good-quality ration to female and castrated male black-tailed deer (34) in restricted amounts to give liveweight losses of 16, 20 and 33% over a four month period during winter, resulted in the 'high intake' deer losing less body fat (38%, v. 67% for the 'low intake' deer). However, the 'low intake' animals lost more protein and the carcases finally had similar fat contents of about 8% (35). It is interesting that deer apparently mobilise glucogenic amino acids effectively during feed shortages and thus are not prone to ketosis (36). There may be a subtle effect on the amino acid content of the remaining protein—the glucogenic amino acid alanine (a non-essential amino acid) is the first to be metabolised (34).

Feed restriction to 20% of maintenance without changes in diet composition (37) caused female red deer to lose muscle mass through a reduction in the size of muscle cells (as indicated by changes in muscle protein:DNA ratios). The rut in red males (19) reduced fat depot size through reductions in fat cell size (mean of 93% reduction) and number (up to 86% in subcutaneous fat). Although food restriction reduces body size and fatness, red stags at least will compensate if re-fed on good-quality food during their second year (38). Fully compensated animals had more perirenal fat than stags of nearly similar size, grown at more modest rates.

Consistent with the data on food restriction presented above, both New Zealand (39) and Danish (40) workers have shown that feeding systems which provide more abundant nutrients grow fatter animals. The NZ red weaners ate more red clover than ryegrass/white clover, with both hinds and stags being heavier, and the stags slightly fatter, at one year old. In the Danish work, fallow deer weaners which were given a 90:10 grain/protein meal diet had a significantly poorer carcase grading for fatness (they were overfat) than animals which had been fed pasture during summer. Individually fed rusa stags at Gatton (13) gained weight (106 g/d) when fed lucerne hay (*Medicago sativa*; 54% cell walls) without restriction, but lost weight (-80 g/d) when given Rhodes grass hay (*Chloris gayana*; >80% cell walls) under the same conditions. Thus deer grow faster, and may become fatter, when given better quality food. This may simply reflect the positive relationship between carcase fatness and body size described in red deer (12).

Cholesterol

Dietary cholesterol is often avoided because of its presumed relationship with coronary heart disease. Red deer venison has between 66 and 74 mg cholesterol/100 g of lean meat (4), sambar (*C. unicolor*) has 58mg/100g (41). These values are similar to those for mutton (41) and beef (4, 41). Venison from game fallow (10) and white-tailed deer (42) may have 30 to 70% more cholesterol than comparable farmed animals. The cholesterol content of muscles from farmed Javan rusa deer has been extensively studied (13). Cholesterol tended to increase with age, and to be highest in the neck and chuck cuts, but there was no correlation with increasing body fat content. Cholesterol contents were between 51 and 79 mg/100 g.

Fatty acids in venison

ω3 fatty acids ameliorate or prevent disorders such as rheumatism, heart disease, etc (43). These nutrients are precursors of the eicosanoids (44) but they can not be synthesised by mammals, which are unable to insert double bonds between the ω9 C and the terminal methyl group. Thus linoleic, linolenic and arachidonic acids are essential in the human diet. The occurrence of these fatty acids in the intramuscular fat of the Javan rusa's loin muscle (specifically, the *m. longissimus dorsi*) has been investigated (Table 2). This study confirmed the presence of linolenic acid in grass lipid (about 33% of the total), demonstrated its presence in deer intramuscular fat, and showed that castration tends to reduce the proportion of linolenic acid (and total polyunsaturated fatty acid) in intramuscular fat. Similar levels of linolenic (2.4%) and arachidonic (8.0%) acids, and total polyunsaturates (31.4%) have been reported in lean meat from the sambar deer (41).

Table 2. Polyunsaturated fatty acids in the longissimus dorsi muscle of rusa deer (45)

Age (months)	Polyunsaturated fatty acids (% of total fatty acids)					Ratios		
	C18:2	C18:3	C20:4	C22:5	Total	P+M : S	P : S	P : M
13	17.7	4.5	13.2	0.0	35.4	1.8	1.1	2.3
19	17.2	4.2	9.7	3.2	34.2	2.1	0.9	1.4
25	11.3	3.3	6.3	1.8	22.6	1.5	0.4	0.9

P, polyunsaturated; M, monounsaturated; S, saturated

The values given in Table 2 for polyunsaturated fatty acid contents are lower than the contents of these fatty acids in venison loin muscle phospholipid (4). The animals represented in Table 2 were slaughtered either before or well after the rut, and the data probably reflect the increasing loading of this fat fraction with storage, rather than functional (cell membrane) lipid.

Other fat depots have more saturated and less unsaturated fatty acids (Table 3). The relatively high proportions of saturated fatty acids in visceral and kidney fat are of little consequence for human nutrition as these are not usually eaten. Subcutaneous fat has less polyunsaturated fatty acid than inter- or intra-muscular fat, but the amount of subcutaneous fat is low in deer which have been slaughtered at optimum liveweight and season.

Table 3. Fatty acid composition of longissimus dorsi muscle intramuscular (LD), kidney (KF), visceral (VIS), intermuscular (INT) and subcutaneous (SC) fats of Javan rusa males aged 25 months, reared on pasture (13).

	Fatty acid composition (% of total fatty acids in depot)					
	KF	VIS	INT	SC	LD	SE
Total SFA	72.4^{a}	67.1^{b}	54.37^{c}	51.3^{d}	40.7^{e}	0.99
Total MUFA	25.8^{c}	31.1^{d}	43.5^{a}	46.4^{a}	37.4^{b}	1.24
C18:2c	0.9^{b}	1.1^{b}	1.2^{b}	1.4^{b}	11.3^{a}	0.33
C18:3c	0.9^{b}	0.8^{b}	0.9^{b}	0.9^{b}	3.3^{a}	0.11
Total PUFA	1.8^{b}	1.8^{b}	2.1^{b}	2.3^{b}	22.6^{a}	0.69

^{a,b,c}within rows, means with the same superscript are not significantly different ($P < 0.01$)

Conclusion

Venison has several desirable attributes as a human food. It is equally as good a source of amino acids and minerals as other meats, and it has little fat (and about half of this is in the viscera), moderate cholesterol, and the intramuscular lipid of pasture-reared deer is a source of linolenic and other polyunsaturated fatty acids. Venison from males slaughtered just before the rut (ie in Australia, from red and fallow deer slaughtered in mid-summer and Javan rusa in late autumn) will be from well-grown animals, but venison becomes fatter as animals grow and/or age. Deer production systems will take account of those factors which maximise the efficiency of carcase production. Careful deer farmers will also take advantage of the biology of deer growth, to choose slaughter ages and seasons, and nutritional management, which will optimise carcase fatness and thus maximise the acceptance of venison by fat-conscious consumers.

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