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MEAT PRODUCTION FROM FARMED DEER

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INTRODUCTION

As the New Zealand deer industry develops, there is an increasing interest in the production of venison, as distinct from producing velvet antler and live animals for sale.

The long term viability of any meat production system is dependent on two main factors:

i) Knowledge of consumer demand and the ability to profitability fabricate the required products.

ii) The ability to produce the raw material economically and to specification.

In general terms, the requirements of most of today's more sophisticated markets for meat are that it be lean, tender, attractive, nutritious, consistent and "natural". The market for venison is the top, the high value end of the market. The top end of any market will take only top quality product and demands the highest standards of quality control and quality assurance programmes. Similarly, high value markets for meat usually prefer fresh or chilled rather than frozen product — hence the importance of new developments in processing and packaging.

This paper is concerned with producing a high quality end product from farmed deer (Fig 1). In this paper we consider the system from the raw material to end product, with special emphasis on the control that the farmer has in the production system. Most of the paper will be concerned with red deer, with data on fallow deer provided where available.

THE RAW MATERIAL

The Animal

Seasonality and growth

Both red deer and fallow deer are species of temperate origin and exhibit a very marked seasonal pattern of feed intake and weight change. This has been well studied in red deer and occurs even in young deer fed to appetite, where the cyclical growth pattern is characterised by high rates of weight gain in spring and summer and low gains in winter.

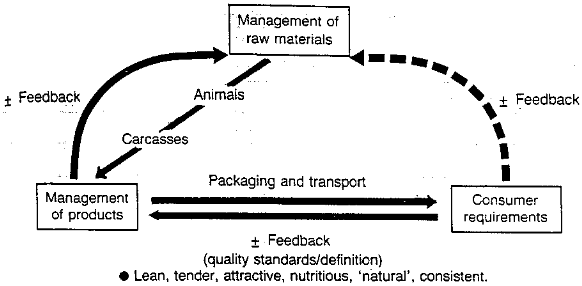

FIGURE 1: THE INTERRELATIONSHIP OF VARIOUS FACTORS IN THE PRODUCTION OF MEAT FROM DEER

The cyclical pattern of weight change is very pronounced in older red stags, who may lose a large proportion of their body weight during the rut and winter. At Invermay, weight losses of over 30% have been recorded in stags over the rut.

The annual pattern of food intake in adult stags is probably best considered as being composed of two cycles superimposed on one another. The basic cycle only is exhibited by females and by young deer of both sexes. The basic cycle with feed intake increasing through spring to reach a maximum in early summer followed by a decline is exhibited by females and by young deer of both sexes. It is essential to appreciate that this basic cycle is fundamental to the animal and is regulated by day length and is not a function of the feed supply although low quality feed can modify the performance. The demands of lactation in the hind result in a high feed intake during the summer where feed of adequate quality is provided. However, feed of inadequate quality can seriously reduce milk production and therefore calf growth rates.

Superimposed upon this basic cycle in the adult male is the sexual cycle. In this case, the rising level of testosterone in the early autumn is associated with a dramatic decline in feed intake with a consequent mobilisation of body reserves and loss of a large proportion of body weight (Fig. 2). When body fat has fallen to a very low level, feed intake increases and the stag, given adequate feed, will maintain body weight through winter.

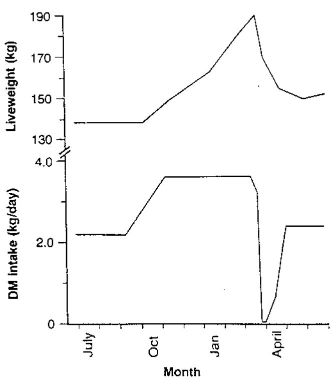

FIGURE 2: THE PATTERN OF LIVEWEIGHT AND FEED INTAKE IN RED DEER STAGS, AGED 2.5 TO 3.5 YEARS

The highly seasonal pattern of growth in young stags, even when fed to appetite, indicates the obvious preferences for the timing of slaughter — such would be at the end of the growth spurts in March at 15 or 27 months of age (Fig. 3). However, we do not live in an ideal world, and the demands of the market place may necessitate slaughter of stags at other times of the year.

Carcass composition

The major selling point of venison is its leanness. This is highlighted in Table 1, where carcasses from red and fallow deer are compared with traditional livestock. Even though the deer have reached 50-70% of their mature body weight, the fat content is very low. The data also suggest that fallow deer may be relatively leaner than red deer at the same proportion of mature body weight, although more studies are required to clarify this aspect.

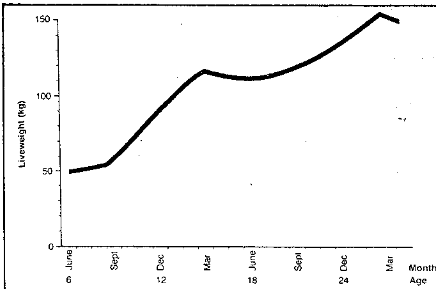

FIGURE 3: THE PATTERN OF GROWTH OF RED STAGS (n = 6) FED A HIGH QUALITY DIET *AD LIBITUM* INDOORS

Table 1: Comparative weight and fatness data for male red and fallow deer compared with ram lambs

	Age	Liveweight		Carcass	
	(months)	kg	% of mature weight	Hot weight (kg)	Fat %
Red stags[1]	14/15	100	50	56.5	9.5
	26/27	132	66	78.0	13.1
Fallow bucks[2]	13	46	51	25.6	6.1
	25	63	70	36.9	10.0
Ram lambs[3]	6	40	36	17.0	21.8

[1] *Drew 1985, mature weight 200kg.*
[2] *McCall 1985, liveweight = 1.06 × fasted weight, mature weight 90kg.*
[3] *P.F. Fennessy, unpublished.*

The relative leanness of deer compared with traditional livestock is especially evident when animals are compared at maturity (Table 2). The seasonal change in composition of the stag's carcass over the period of the rut is also evident. Over this period, carcass weight losses of 28% were recorded in adult stags, with 3/4 of this loss being fat, ie, the stags mobilised 95% of their carcass fat over the rut (Drew 1985). Even though the pre-rut red stag is visually grossly overfat, in comparison with sheep or cattle at maturity it is relatively lean. It is this mobilisation of fat over the rut which provides a second chance to produce lean meat from stags.

Table 2: Comparative composition of cattle, sheep, red and fallow deer at maturity

	Weight (kg)		% Components		
	Fasted live	Cold carcass	Fat	Lean	Bone
Steer[1]	755	505	54	39	7
Ram[2]	98	52	43	46	11
Red stag pre-rut[3]	190	120	21	66	13
post-rut	146	87	1	83	16
Fallow bucks pre-rut[4]	76	51	17	—	—

[1] *Bond et al 1982, Angus steers.*
[2] *Adapted from Butterfield et al 1983 a.*
[3] *Drew 1985.*
[4] *Chemical fat content; K.R. Drew, unpublished (n = 3)*

Castration

Castration is a practice which has no place in normal farm management of deer. Castration, by removing the influence of the male hormones, causes a change in the way the animal utilises its feed such that growth rate declines and the daily rate of gain of lean tissue declines drastically (Tables 3 and 4). In special circumstances, (eg, when slaughtering males at times of the year when their behaviour is inappropriate), castration can be a useful management procedure. However, even in this situation it is essential to consider the fatness of the males at the time of castration. Castration, by eliminating the source of male hormones, will also eliminate the rut, with its consequences for fat mobilisation.

The marked effects of castration on growth rate of stags are accompanied by a remarkable paradox. During the spring-early summer period, when the potential for growth is very high the stag is virtually a functional castrate. This is the period of antler growth when only very low levels of testosterone are present in the blood (Fennessy and Suttie 1985). In fact there is so little testosterone that it is possible to substantially increase growth rate by treatment with testosterone or other growth promoters with a steroid-like action. A comparison of the effects of castration, zeranol and testosterone treatments is given in Table 5. However in the natural product market, there is no place for such growth promoters — consumer perception of the product is the all important issue.

Table 3: Effects of castration on weights in deer (kg)

Age at slaughter (months)	Liveweight		Carcass weight		% Change
	Entire	castrate	Entire	castrate	
Red (castrated at 5 months)[1]					
16	83.8	76.1	43.8	40.6	-7
27	118.1	98.4	67.6	55.8	-17
Fallow (castrated at 7 months)[2]					
20	46.8	41.7	30.4	24.4	-20

[1] *Drew et al 1978.*
[2] *Mulley & English 1985.*

Table 4: Effects of castration on liveweight gain (LWG), carcass weight gain (CWG) and gain of chemical fat, water and protein from 16 to 27 months of age[1]

	LWG	CWG	Components gain (kg)		
	(kg)	(kg)	Fat	Water	Protein
Entire	34.3	24.2	5.46	13.00	4.48
Castrate	22.3	15.2	3.00	8.37	2.93

[1] *Adapted from Drew et al 1978 (330 day period).*

Table 5: Effect of castration or hormone treatment on the rate of liveweight gain (LWG) of rising 2 year old red stags in spring.

	Expt 1[1]		Expt 2[2]		Expt 3[3]	
	Castrate	Entire	Entire	Zeranol	Entire	Testosterone
N	5	6	8	9	8	15
Period (days)	91		56		52	
LWG (g/day)	201	266	330	294	203	264
Relative LWG	76	100	100	119	100	130

[1] *Drew et al 1978, from early September.*
[2] *P.F. Fennessy and G.H. Moore (1977 unpublished); 12 mg Ralgro, Cooper Wellcome given subcutaneously on 13 October).*
[3] *Suttie et al 1985 — stags were implanted subcutaneously on 26 October with 2 or 4 silastic tubes packed with testosterone.*

Musculature

The high priced cuts from any meat animal come from the hind leg and the back around the spinal column although in large animals such as cattle, some of the muscles of the forequarter also achieve a high-priced status.

Table 6: Comparative muscle weight distribution of mature red deer stags, rams and bulls.

	Muscle group as % of total muscle			Relative weight	
	Stags[1]	Rams[2]	Bulls[3]	Stag/Ram	Stag/Bull
Pelvic (proximal hind)[4]	28.8	24.9	24.4	116	118
Crural (distal hind)	4.9	4.4	3.1	113	159
Spinal	12.3	13.5	9.6	91	128
Sublumbar	2.5	2.0	1.8	126	139
Spinal and sublumbar	14.8	15.5	11.4	95	130
Abdominal	5.9	10.6	9.0	56	65
Brachial (proximal fore)	10.7	10.8	11.4	99	95
Anterbrachial (distal fore)	2.4	2.7	1.9	87	124
Extrinsic forelimb	14.4	16.2	19.2	88	75
Neck	12.3		14.2		
Thoracic	4.1		5.2		
Neck and thoracic	16.4	12.4	19.4	132	85
Scrap	1.7	2.5	0.2		

[1] *Wallace 1983, 6 stags around the rut.*
[2] *Calculated from Butterfield et al 1983, 10 mature rams.*
[3] *Tan 1981, 2 mature Jersey bulls.*
[4] *Muscle groups as defined by Tan (1981).*

Unfortunately there are no data for complete muscle dissection available for fallow deer. However there is some information for individual muscles of the hind leg and saddle (Table 7). These data suggest that the muscles of the hind leg and saddle may be proportionately larger in fallow than in red deer.

However, this suggestion does not receive any support from data for the proportions of commercial cuts for the carcasses of red and fallow deer (Table 8), where for both species, the hind leg and saddle form proportionately similar amounts of the carcass. The major difference between the two species is the flap region, which raises questions about possible differences in the system of carcass cutting. The small number of animals involved is also of concern.

Table 7: Comparison of muscle weights in male fallow and red deer

	Fallow[1]		Red	
	13m	25m	27m[2]	Adult[3]
Side lean (muscle) weight	9.4	12.6	24.5	34.7
Side weight	12.4	17.9	34.5	45.9
Muscles (% side lean)				
Hindquarter				
Semitendinosus	2.04	2.07	2.05	2.05
Semimembranosus	6.96	6.78	5.03	5.23
Gluteobiceps	7.71	7.91	6.69	6.64
Quadriceps femoris	8.89	8.44	7.34	6.82
Other				
Longissimus	8.83	8.78	—	7.93

[1] *McCall 1985; the 4 hindquarter muscles accounted for 61% of the total dissected muscle from the hindquarter cut.*
[2] *Tan and Fennessy 1981*
[3] *Wallace 1983*

Table 8: Commercial primal cuts (untrimmed) as a proportion of carcass weight.

	Fallow[1]		Red[2]	
	13	25	15	27
HCW	25.3	36.4	—	—
CCW	24.7	35.6	51.9	67.7
N	8	8	5	4
Cuts (% of CCW)				
Neck	11.2	11.6	12.6	13.7
Shoulders	18.0	17.2	19.3	19.0
Saddle	15.2	15.6	15.0	16.0
Flaps	15.0	16.7	13.7	10.9
Hindlegs	40.6	39.0	39.4	40.6

[1] *McCall 1985*
[2] Drew unpublished

Animal management

Animal management also has a considerable role to play in producing a high quality product. Bruising and carcass damage prior to slaughter can result in significant losses to the producer. Therefore it is essential that all stags and bucks have their antlers removed prior to transport. With fallow deer, it may be profitable to amputate the pedicles at a very young age (Asher 1985). The timing of slaughter is also important — obviously one could expect a large amount of bruising and carcass damage if mature stags are slaughtered in May-June.

THE CARCASS

Slaughter and dressing

The level of bacterial contamination of the carcass during the slaughter and dressing procedure can have a considerable impact on the quality of the product long term, ie, the shelf-life of the product. Therefore, minimising the risk of contamination by washing animals well before slaughter is important. In addition, the actual dressing procedure can have a major impact on bacteriological quality of the carcass. In this respect, recent work by Miller's MechanicalLtd working at Invermay is relevant. Milmech, in association with Invermay and the Department of Trade and Industry's Prototype Development Fund, have designed, built and tested new machinery for dressing deer carcasses in the inverted position (ie, held by the front legs during hide removal). The development has been very successful with the first commercial plant expected to be in operation in December.

Post-slaughter treatment

Tenderness is the most important consideration in the eating quality of meat. Consequently it is essential that we understand how to produce a consistently tender product. This is where the modern technologies of accelerated conditioning and controlled ageing can make a major impact on product quality. If meat is chilled prior to **rigor mortis,** it undergoes a contracture of the muscles — it is this contracture (cold shortening) which produces the pronounced toughening on cooking. **Rigor mortis** begins as the muscles are starved of oxygen post-slaughter. The biochemical changes which occur include the complete disappearance of ATP and creatine phosphate, and the production of lactate from the glycogen. The pH of the muscle is related to this accumulation of lactate ions — if the animals are stressed pre-slaughter, the glycogen stores are reduced and consequently lactate production is reduced — hence high pH meat.

Cold shortening occurs due to a massive increase in the concentration of calcium ions in the myofibrillar region through discharge of calcium from the sarcoplasmic reticulum. The magnitude of cold shortening increases with falling temperature. At 15-20°C very little shortening occurs during rigor, but as the temperature declines, the extent of shortening prior to and during **rigor mortis** increases markedly. Ageing is the process of allowing post-rigor muscle exposure to the atmosphere for a number of days prior to cooking — the result is usually an appreciably more tender product.

Davey and Chrystall (1980) conclude that two clear processing requirements have arisen from a knowledge of rigor development, muscle shortening and meat ageing:

- ★ chilling of freezing of carcases should take place after the completion of rigor development,
- ★ only then is maximal tenderising of meat achieved through ageing.

Tough meat can be produced very simply by chilling or freezing a carcass before the process of **rigor mortis** is complete. Electrical stimulation is a very useful process designed to accelerate **rigor mortis** in carcasses. At Invermay, we use a low voltage system (80v, 0.6A peak) which is applied 30-60 seconds after bleeding out. The electrical contact is provided via a nose clip and the hind leg.

Studies at Invermay have been concerned with defining the influence of electrical stimulation and the freezing/thawing cycle on the tenderness of loin sections (Table 9). The data indicate the very marked effects of electrical stimulation on tenderness. Freezing and thawing did apparently improve the tenderness of venison while in the case of electrically-stimulated meat, slow thawing produced a more tender product than rapid thawing.

Tabe 9: Effect of electrical stimulation and freezing and thawing on the tenderness[1] of loins of venison[2]

	Expt 1 (26m)[3]		Expt 2 (17m)		
	Fresh	Frozen (slow thaw)	Fresh	Frozen (rapid thaw)	Frozen (slow thaw)
Non-stimulated	11.7	10.8	11.0	9.3	9.6
Stimulated	6.0	5.2	7.9	7.2	6.0

[1] *Tenderness measured as Warner-Bratzler shear force; ie, the force required (kg) to shear a piece of meat cooked for 60 minutes at 80°C — very tough meat would require 14-15kg and very tender meat, 3-4kg.*
[2] *All carcasses held at 10°C for 2 hours and then at 0°C for 22 hours prior to testing or freezing.*
[3] *Age in months.*

Grading

The market requirements for a lean product mean that it is absolutely essential that the carcass grading system identify the suitable export grade carcasses. The current industry grading standards put out by the Game Industry Board are given in Table 10.

The AP carcass classification indicates prime quality (lean with good muscle). The TD measurement is the depth of tissue over the 12th rib at a point 16 cm round from the midline; alternatively it may be taken in line with a drop from the pin bone of the hip. The TD is a tissue depth, not a fat depth — as animals fatten, the proportion of fat in this position increases while the thickness of muscle stays relatively constant. Consequently the TD reflects fat content of the carcass. Figure 4 shows the relationship between TD and carcass fat content for red deer stags.

Table 10: Grading standards for New Zealand deer carcasses.

Grade	Carcass weight (kg)	Tissue depth limit for overfatness (mm TD)
AP1	>70	14
AP2	50.5-70	12
AP3	<50	10
AF Undamaged overfat		
AD Overfat with one primial cut damaged		
AM Manufacturing (damaged, emaciated, aged, discoloured)		

The sliding scale TD in the grading system recognises the fact that heavier animals will have a greater tissue depth than lighter animals even in the total absence of any fat. This is very important in the grading of older stags post-rut and will become even more important as increasing numbers of the larger strains of deer, such as wapiti hybrids are slaughtered for venison production.

In the longer term it will be desirable to develop a grading scheme to pay farmers on an estimated lean meat yield. Currently we are evaluating the Hennessy-Grading probe on deer carcasses as we believe it is this sort of technology which will enable development of a better grading-payout system. Such a system would take into account carcass weight and a fat (or lean) assessment in order to calculate an estimated lean yield from a carcass. Where trimming is required, deductions in the payout could be made simply.

THE PRODUCT

Consumer Requirements

The consumer seems to want venison products which are lean, tender, attractive, nutritious, "natural" and consistent. To produce a lean, attractive product requires that animals be slaughtered at an appropriate weight and at an appropriate time of the year. Trimming of fat from a carcass certainly affects the appearance of the meat and therefore should be avoided. At the top end of the market, the demand is for chilled rather than frozen venison. Therefore an understanding of the factors which affect the quality of chilled meat is essential. For this reason, there is an extensive research programme covering such things as tenderness and shelf life, underway at Invermay.

Worldwide, the more sophisticated consumers are suspicious of food additives, growth promoters, etc. Regardless of whether there is any scientific basis for their concern, it ill behoves any farmer not to take notice of their concerns. There is simply no point in producing something if you cannot sell it. Therefore it is essential for the venison industry in New Zealand to have nothing to do with growth promoters.

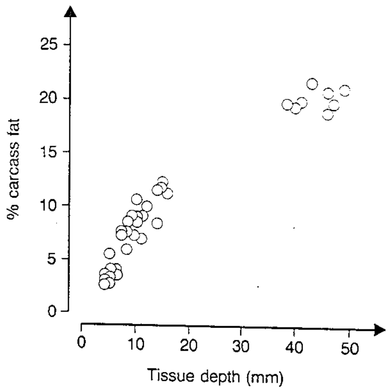

FIGURE 4: RELATIONSHIP BETWEEN CARCASS FAT PERCENTAGE AND THE TD (FATNESS ASSESSMENT) IN RED DEER STAGS OF VARIOUS AGES.

In any market, it is also vitally important that the product be of good, consistent quality. The purchaser must be sure that the product will be of similar quality on each occasion it is purchased. Consequently, appropriate methods of quality control must be in place. However, in addition, cooking methods are also important — any cook can abuse a fat product without rendering it completely inedible. There is no such room for error with a lean product such as venison. Therefore consumer education will form a vital part in the long term development of retail as distinct from restaurant markets.

Product Definition

Throughout the western world, there is a steady growth in "nutritional awareness" particularly as food quality and composition are perceived to affect one's health. Venison is a lean product and can be confidently marketed as such so long as there is an appropriate grading system to ensure that the product is always lean.

There is a need for data on the nutritional analysis of venison to be readily available. The information required includes the contents of fat, water and protein along with minerals, vitamins, cholesterol and particular fatty acids. It is essential that this information be derived in reputable laboratories.

CONCLUSIONS

Venison as a lean, attractive product has a bright future so long as the industry, from producers to marketers, is prepared to produce and market it on its strengths.

REFERENCES

Asher, G.W. 1985: *The Deer Farmer No. 27:* 33-35.

Butterfield, R.M.; Zamora, J.; James, A.M.; Thompson, J.M. and Williams, J. 1982: *Anim. Prod. 36:* 165-174.

Davey, C.L. and Chrystall, B.B. 1980: *Ann. Technol. Agric., 29:* 547-561.

Drew, K.R. 1985: *In:* Biology of Deer Production. P.F. Fennessy and K.R. Drew editors, *Roy. Soc. N.Z. Bull. 22:* 285-290.

Drew, K.R.; Fennessy, P.F. and Greer, G.J. 1978: *Proc. N.Z. Soc. Anim. Prod. 38:* 142-144.

Maiga, A.M. 1974: Ph.D. thesis, Cornell University, Ithaca, New York.

McCall, J.E. M.Agr.Sc. thesis, Massey University, Palmerston North.

Mulley, R.C. and English, A.W. 1985: *Anim. Prod. 41:* 359-361.

Suttie, J.M.; Corson, I.D.; Gray, M.; Gluckman, P.D.; Elgar, H.J. and Lapwood, K.R. 1985: *Proc. Endo. Soc. Aust. 28, Suppl. 2:* 35.

Tan, G.Y. 1981: Ph.D. thesis, Massey University, Palmerston North.

Tan, G.Y. and Fennessy, P.F. 1981: *N.Z. J. Agric. Res. 24:* 1-3.

Wallace, V. 1983: B. Phil. thesis, Massey University, Palmerston North.

Wallace, V. and Davies, A.S. 1985: *In:* Biology of Deer Production. P.F. Fennessy and K.R. Drew editors, *Roy. Soc. N.Z. Bull. 22:* 291-293.