VENISON RESEARCH - CARCASS FEATURES PROCESSING AND PACKAGING

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SUMMARY

Venison is seen as a high value gourmet product notable for its leanness. Stags are markedly leaner than bulls or rams, while there is generally proportionately more high value musculature in the carcass of a deer than a bull or ram of comparable maturity. Deer have a highly seasonal growth pattern and mature stags deposit large amounts of fat during the summer which is almost totally lost during the 6 week breeding season.

Efforts are now being made to devise a carcass grading system that will provide an accurate estimation of carcass lean content, so that producers can be paid for producing lean meat.

The most attractive high value meat products are generally chilled rather than frozen with shelf life determined by bacteriological quality after slaughter, handling during cutting and packaging, and the storage conditions. Results are presented that indicate the effect of various post-slaughter treatments on carcass quality.

As volumes of farmed venison increase it will become important to investigate a range of options for cutting, processing and packaging chilled and frozen venison. Some possibilities are presented in this paper.

INTRODUCTION

It is clear that within the next few years there will be a very marked increase in the production of New Zealand farmed venison. Consequently we have only a few short years to further our market research, extend market promotion, identify the preferred customer products and establish good methods for quality control of venison products. Currently most of the venison going into North America is airfreighted in the chilled form whereas that going to the traditional German market is frozen.

The major selling point for venison is its leanness - therefore it is absolutely essential that this be maintained through quality control. The top end of any market will only take top quality product - hence the relevance of a good grading system.

Future prospects for venison sales to the top of the market must be centred around chilled rather than the frozen product. Therefore much of the venison product research must be centred around understanding the factors which govern the shelf-life of the chilled product - the payoff will be in producing a consistent product with a long shelf life.

When it comes to eating meat, tenderness is probably the most important consideration for the consumer. Consequently knowledge of the influence of post-slaughter treatment on tenderness is essential to the future well-being of the export venison industry.

With any meat animal product, some parts of the carcass are perceived by the customer as being of intrinsically higher quality than others - the problem for the producer and marketer is that animals do not produce all saddles and hindlegs. Therefore methods of upgrading the lower quality portions of the carcass by further processing are very important.

This paper describes research designed to ensure that New Zealand venison is seen by customers as a top quality product which is well worth a substantial price premium.

CARCASS COMPOSITION AND GRADING

Fatness in young stags

The highly seasonal pattern of growth of red deer indicates the obvious options for timing slaughter of young stags - namely at the end of the spring-summer growth 'spurts' in March at 15 or 27 months of age. Even though such stags will have reached 50-55%(at 15 m) or 65-70% (at 27 m) of their mature weight, they are still very lean when compared with traditional livestock (Table 1). Even so some of the 26/27 month old stags, particularly the heavier ones may be overfat when offered for slaughter in February-March.

Despite the obvious advantages from the farmers' point of view of slaughtering stags at the end of their growth spurts, market requirements are likely to dictate otherwise. As year-round markets develop for chilled venison it will become essential to spread the kill. Price to the farmer is the obvious mechanism to ensure that supply and demand are as evenly matched as possible. From the production point of view, non-hormonal manipulations of the growth pattern of young stags, to ensure that they continue to grow during their second winter would be a major step forward.

TABLE 1 Weight and fatness data for red deer stags compared with ram lambs and bulls

	Age (months)	Liveweight kg	Liveweight % of mature weight	Hot carcass weight (kg)	Fat %
Red deer stags[1]	14/15	100	50	56.5	9.5
	26/27	132	66	78.0	13.1
Ram lambs[2]	6	40	36	17.0	21.8
Bulls[3]	14	310	62	186	17.7

1 Drew 1985; Drew and Fennessy, unpublished
2 Fennessy, unpublished
3 Maiga 1974 Angus bulls

Musculature

The muscle distribution of the stag carcass is also advantageous when compared with sheep and cattle with a higher proportion of the musculature being in the higher priced areas of the carcass (Table 2). In these data, the high-priced muscle groups of the hind-leg are relatively 16-18% heavier in the mature stag compared with the mature bull and ram. The muscles of the saddle area (spinal and sublumbar groups) also form a substantially greater proportion of total muscle in the stag than in the bull but are similar in the ram and stag. Such muscle development is simply the deer's response to its evolutionary environment - it attempts to escape its predators.

TABLE 2 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
Abdominal	5.9	10.6	9.0	56	65
Brachial (proximal fore)	10.7	10.8	11.4	99	95
Antebrachial (distal fore)	2.4	2.7	1.9	87	124
Extrinsic forelimb	14.4	16.2	19.2	88	75
Neck	12.3	))12.4)	14.2	132	85
Thoracic	4.1		5.2		
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)

The older stag

The highly seasonal pattern of weight change in the adult red deer stag, highlighted by the dramatic weight loss over the rut, is accompanied by similarly dramatic changes in carcass composition (Drew 1985). Table 3 presents data from carcass dissection of mature stags pre- and post-rut, showing that 95% of all dissectable carcass fat was lost by the stags over the period of the rut.

TABLE 3 Composition of adult stags pre- and post-rut from carcass dissection

	Weight (kg)		
	Pre-rut March	Post-rut May	Loss %
Live weight	203	151	25
Carcass weight	122	87	28
Carcass lean	80.5	72.4	10
Carcass fat	25.4	1.2	95

This fat mobilisation does provide a second chance to produce a very lean product by slaughtering older stags during winter.

Carcass 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 4.

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 1 shows the relationship between TD and carcass fat content for red deer stags.

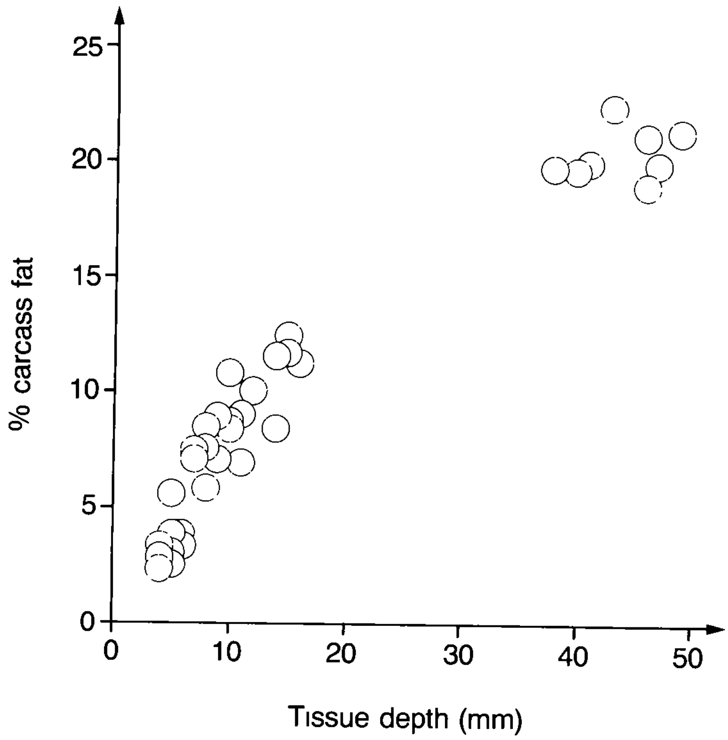

FIG. 1 Relationship between carcass fat percentage and the TD (fatness assessment) in red deer stags of various ages.

Table 4 Carcass grading standards

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 meat yield from a carcass. Where trimming is required, deductions in the payout could be simply made.

Carcass size

Currently there is considerable interest among farmers in hybridisation of the local New Zealand red deer with larger strains such as European reds or North American wapiti to increase growth rate and size. The question of carcass size of hybrids, especially wapiti, in terms of market requirements is controversial. Exporters prefer even lines of product, especially where exports are as primal cuts. Therefore one problem has been the very small quantity of these large animals offered for slaughter. However, as the numbers increase, it is envisaged that this will be much less of a problem. Also, as markets develop and portion cutting in the processing plant becomes more important, then carcass size becomes much less of a question as the product can be cut to the size required by the market. Indeed some would argue that there may even be positive advantages in the large size, since the customer may prefer cuts which are close to the familiar beef size.

PROCESSING VENISON

Bacteriological quality

The top end of the market prefers a chilled rather than frozen product. Therefore processing developments which lengthen shelf life have much to offer the industry.

Shelf life is determined by a number of factors, the most important being:

* the bacteriological quality of the carcass off the slaughter line
* handling during packaging
* storage conditions

Guidelines from the chilled beef and lamb industries indicate that acceptable bacterial levels at packing for export are 10^4 - 10^5/cm^2 for beef and 10^3-10^4/cm^2 for lamb.

In 1983, we conducted experiments at Invermay to study the shelf life of carefully slaughtered and vacuum-packaged venison. Results showed that up to 10 weeks storage at -1°C could be achieved with bacterial counts not exceeding 10^5/cm^2. During weeks 11-14, counts increased to about 10^6/cm^2, but at no time did any samples show any obvious deterioration in terms of odour or pH. However, in 1984, further work was carried out and although the bacteriological quality of the carcass off the slaughter line was as good as in 1983, shelf life was less than 2 weeks. Obviously there were contamination problems during cutting and vacuum packaging. Clearly attention to detail in all facets of handling chilled meat is essential in achieving an extended shelf life.

The actual dressing procedure for the carcass can have a major influence on the amount of contamination on the carcass leaving the slaughter line. In this respect, recent work by Millers Mechanical 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 and measurements of bacteriological quality of the carcass have shown that loin and leg pieces have barely detectable bacterial counts (average of $10^1/cm^2$, ranging up to $10^2/cm^2$). This virtually sterile carcass must provide an excellent starting point for technologies designed to extend the shelf life of chilled venison. (Note: a 10 minute video production showing the process is available on application to Millers Mechanical via Invermay).

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 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. However, 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 Chyrstall (1980) conclude that two clear processing requirements have arisen from a knowledge of rigor development, muscle shortening and meat ageing.

* chilling or freezing of carcasses should take place after the completion of rigor development

* only then is maximal tenderising of meat achieved through ageing.

Studies at Invermay in 1983 were concerned with the influence of several factors on tenderness.

* the effect of low voltage stimulation
* the effect of storing cuts of venison for varying times and at varying temperatures.
* the effect of freezing and thawing

Tough meat can be simply produced by 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. In the Invermay work, a low voltage system (80V, 0.6A peak) was applied, approximately 30-60 seconds after bleeding out; electrical contact was provided via a nose clip and the hindleg.

Within about 30 minutes of slaughter, the carcasses were cut into the various primal cuts and the loin (saddle) and hind leg subject to other experimental conditioning and ageing treatments.

Electrical stimulation was very effective in improving tenderness, especially in the loin section (Table 5). The loin pieces were generally tougher than the leg, possibly because the small loin pieces cooled more rapidly than the whole legs.

TABLE 5 The effect of low voltage electrical stimulation on meat tenderness[1] in red deer stag carcasses.

	Loin		Leg	
Age	15 m	26 m	15 m	26 m
Non-stimulated	10.6	11.7	6.2	4.8
Stimulated	5.3	6.0	4.1	4.2

1 Tenderness measured as Warner-Bratzler shear force; i.e. the force required in kg to shear a slice of meat cooked for 60 minutes at 80°C - tough meat would require 14-15 kg and tender meat 3-4 kg.

Further improvements in tenderness can be obtained by slowing down the cooling process. Conditioning (holding at 10°C for 24 hours) improves tenderness, while ageing the carcass by storage at 2-4°C for a further period can also be expected to improve tenderness. The following treatments were applied in these Invermay studies.

CA1 - standard treatment:	2 h at 10°C + 22 h at 0°C
CA2	24 h at 10°C
CA3	24 h at 10°C + 24 h at 4°C
CA4	24 h at 10°C + 72 h at 4°C

The combined results of both electrical stimulation and the further conditioning and ageing treatments are shown in Fig. 2.

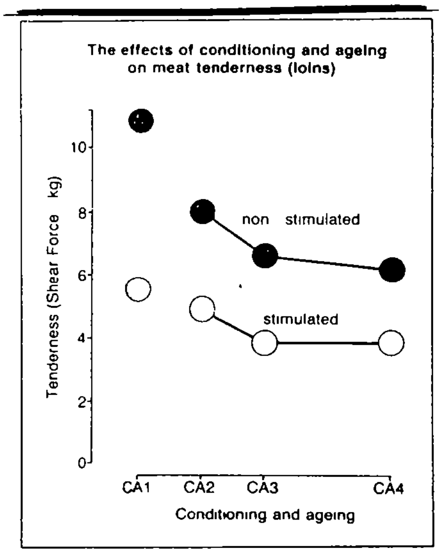

FIG. 2 The effects of the various conditioning and ageing treatments on loin sections from non-stimulated and electrically stimulated carcasses of 15 month old red deer stags. [With permission and acknowledgement to The Deer Farmer No. 22, 1984]

The results show clearly that the conditioning and ageing treatments did affect tenderness of the carcass cuts. Although the effects were more marked in cuts from non-stimulated carcasses, worthwhile improvements were also recorded in those from stimulated carcasses.

Chilled venison

The work on chilled venison has already been mentioned in relation to bacteriological quality. Following the CA1 treatment (2 h at 10°C + 22 h at 0°C), legs and loin were vacuum packed and held at 1°C for up to 14 weeks. Every week, packages of legs and loins were taken from the chiller, opened, sampled for bacteriological measurement and then cooked for tenderness assessment. Figure 3 presents the results for tenderness over the 14 week period.

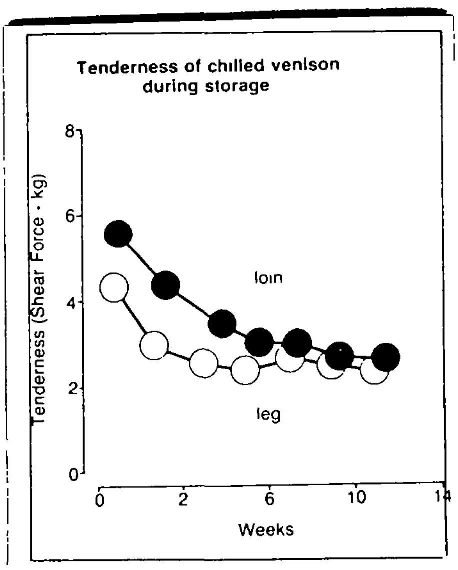

FIG 3. Tenderness of chilled loin and hind leg cuts from 15 month old stag carcasses at various stages during storage at -1°C. The prechilling treatment was CA1 - 2 h at 10°C + 22 h at 0°C. [With permission and acknowledgement to The Deer Farmer No. 22, 1984]

The results indicate that both legs and loins improved in tenderness during the first 7 weeks of chiller storage. It is possible that meat giving tenderness values of <3 is overtender and almost "mushy". If this develops as a problem in chilled venison held for a long time in storage it may be helpful to reduce the extent of conditioning and use a treatment such as CA1, namely 2h at 10°C followed by 22h at 0°C.

New product development

As venison production increases it will be desirable to have as many options as possible for processing and packaging the normally lower-priced portions of the carcass, such as the shoulder and boneless pieces.

Some plants are already involved in such upgrading processes. Examples include boning out of the shoulder, netting it and massaging into a rolled form. It is also possible to 'seam out' the shoulder muscles, remove the muscle sheath by the use of a freezer plate and cutting blade before packaging as "steaks".

Hot boning of carcasses is already carried out in some plants. The advantages include the fact that the quality of lean meat soon after slaughter is more suitable for rolling or restructuring than boneless chilled meat.

Boneless shoulder and/or boneless neck and flaps can also be "flaked" and formed into restructured steaks. This procedure could probably handle the excessively fat boneless product from overfat animals such as summer-slaughtered old stags, where the fat could be removed prior to restructuring.

Vacuum packaging is the current method of choice for packing chilled product. However recent research developments in the lamb industry have shown the potential of packaging meat in oxygen permeable film enclosed in an aluminium foil bag in a carbon dioxide atmosphere. When the aluminium bag is opened, the meat is allowed to slowly equilibrate with the atmospheric oxygen. Using this system, meat colour is greatly improved.

Another possibility is the use of acetic acid treatment where a dilute solution of acetic acid is applied to the surface of the meat prior to packaging. Studies in beef and lamb have shown that such treatment improves shelf life of vacuum packed chilled meat. The treatment apparently causes little discolouration and no odour of the acid is evident on opening the packs. The acetic acid treatment has a bacteriostatic effect on a range of bacteria within the vacuum pack. Consequently, when the packs are opened, storage life of the opened product can also be expected to be increased.

Irradiation of product, as now approved for a wide variety of food products in the US, including pork, provides another possible approach to extending shelf life.

CONCLUSION

Much work needs to be done yet to establish N.Z. farm raised venison as a really top international meat product with excellent nutritional characteristics but there is every indication that the N.Z. deer industry understands the tasks in front of it and is moving in the right direction.

REFERENCES

Butterfield, R. M.; Zamora, J.; James, A. M.; Thompson, J. M.; and Willaims, J. 1983: *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.

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

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

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.