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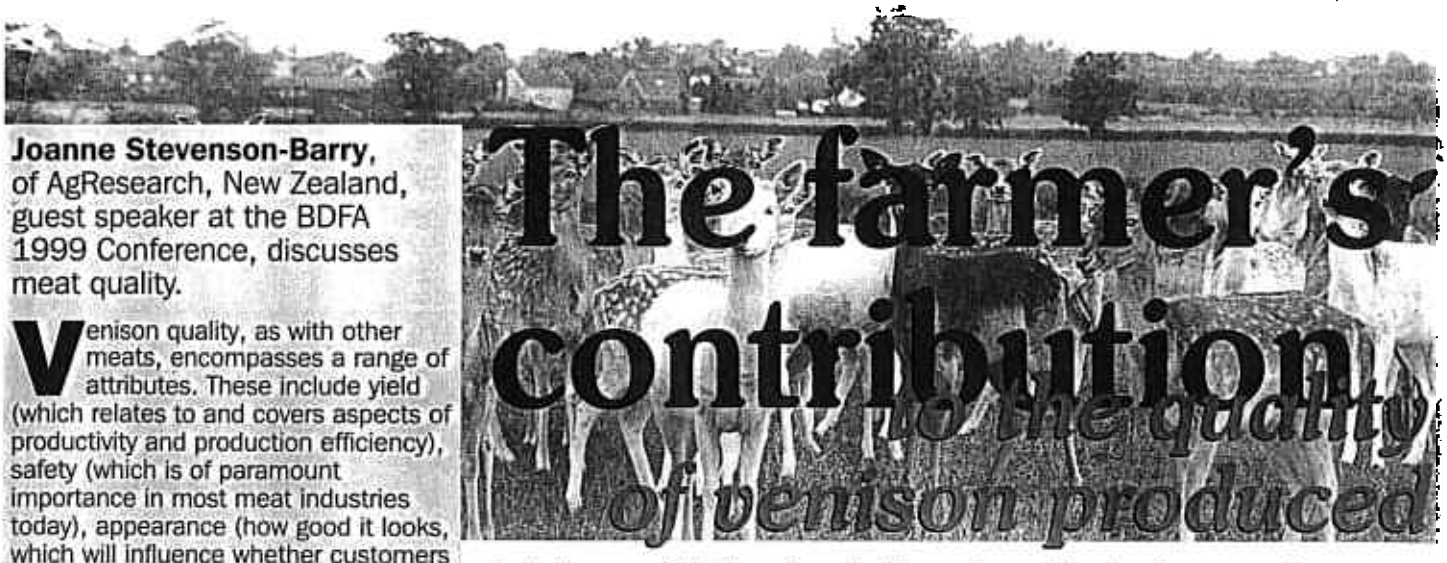

The farmer's contribution to the quality of venison produced

Joanne Stevenson-Barry, of AgResearch, New Zealand, guest speaker at the BDFA 1999 Conference, discusses meat quality.

Venison quality, as with other meats, encompasses a range of attributes. These include yield (which relates to and covers aspects of productivity and production efficiency), safety (which is of paramount importance in most meat industries today), appearance (how good it looks, which will influence whether customers want to buy it) and palatability or eating quality (which relates to the overall enjoyment of the eating experience and how good it tastes, smells, looks, and how juicy, tender and flavoursome it is). Last but certainly not least, is image. This covers aspects such as consumer perception of the product for example healthiness or perceived healthiness, aspects of production such as animal welfare, pasture-raised vs feedlot, and, particularly in the case of venison, a gourmet image.

Below is part one of a two-part article. See the follow-up in the summer issue.

Yield

Yield has been reported to be affected by condition and age of animal (Blaxter *et al*, 1974; Kay & Staines, 1981; Drew, 1985). Farmed red deer have been found to have carcass yields of 54-59%, increasing with increasing animal age (Drew, 1985) which are higher than those reported for other domestic meat-producing ruminants. The carcass yield can be affected by the gut fill of the animal at the time of liveweight measurement and sometimes wet hides can affect the ratio of liveweight to carcass weight.

Dehydration can also affect both the liveweight and carcass weights. Dehydration of live animals can be caused by exercise and stress prior to slaughter and can be reduced by good handling practices. Dehydration of carcasses during chilling can be minimised or eliminated by spray-chilling of water onto carcasses while they are chilling. Spray-chilling can reduce weight loss in the chillers, but in most countries you are legally not allowed to add any weight to the carcass, so this method cannot overcome any dehydration that occurred prior to chilling. Carcasses normally lose around 2% overnight in chillers and spray-chilling can reduce these loses to as little as 0.05%.

Another measure of yield is the percentage of high value cuts. Deer have been found to have a different muscle distribution compared to cattle, with a greater proportion of high value cuts (Drew, 1985). The percentage of saleable meats is another measure of yield and this can be affected by any damage and contamination that needs to be trimmed and discarded. Damage such as bruising and broken bones are indications of poor handling and have both welfare and economic consequences. Contamination can occur via a number of ways and cleanliness pre-slaughter and within the slaughter environment is an important factor. The gut-fill of the animal can contribute to carcass contamination and reduction of gut contents by holding animals overnight at slaughter-plants prior to slaughter, with access to water but not food, is a common practice.

Lean, fat and bone comparisons with Angus bulls have shown that the lean/bone ratio is more favourable in deer, and young red deer carcasses have 50-80% less carcass fat than sheep and cattle. However, fatness in deer is strongly influenced by season. In studies of mature red deer, stags slaughtered pre- and post rut, those slaughtered immediately after the rut (at the beginning of winter) had 25-30% lower carcass weights than those slaughtered pre-rut (autumn) (Stevenson *et al.*, 1992). The total carcass fat decreased over the rut from 21% to 1.3%. GR measurement (a measure of bodywall thickness above the 12th rib and an excellent indicator of fatness) decreased from 31 mm to 5 mm. The striploin weights decreased by 17% and the percentage of intramuscular fat in the striploin decreased from a lean 2.6% to a very lean 0.4%. Hence, the farmer can influence this aspect of quality by determining which time of the year that animals are slaughtered.

Table 1: Seasonal variation in venison carcass and muscle quality from mature red deer stags.

	Pre-rut	Post-rut
Carcass weight (kg)	125	90
Carcass fat (%)	20.8	1.3
GR (mm)	31	5
Striploin weight (kg)	3.0	2.5
Intramuscular fat (%)	2.6	0.4

From: Stevenson *et al.*, 1992.

Safety

Safety of product begins with on-farm practices to ensure that livestock are not diseased or stressed entering the food chain. Transport can affect the safety of the meat due to the stressfulness of it and possible faecal contamination due to close contact whilst in transport. Any faecal contamination on the meat is a concern for food safety.

During processing, hair from skin of deer is a major source of bacterial contamination and water spraying/misting of animals prior to slaughter is believed to reduce hair dispersal. Inverted dressing of carcasses reduces microbial contamination, particularly of the high value saddle and hind leg cuts. Vacuum packaging of product enables longer shelf life, but requires strict storage and distribution temperature control. Rapid chilling of carcasses reduces microbial growth and electrical stimulation is used to ensure that the rapidly chilled carcasses produce tender meat. In New Zealand, carcasses are required to be chilled to a deep bone temperature below 7°C within 24 hours. Most product is chilled to 2-5°C within this period and boning usually commences at about 24 hours after slaughter. Meat is packaged in vacuum packages and chilled to –1°C, a temperature it stays at for the remainder of its chilled storage ideally.

Animals that are stressed can result in meat with higher ultimate pH and higher bacterial contamination. pH is a measure of acidity of the meat. Under-nourishment, stress and over-exercise reduce an animal's energy store (glycogen). After death, muscle glycogen is converted to lactic acid. If the glycogen store has been reduced, less acid is produced which results in a difference in pH. In the living animal the pH is close to 7 (which is neutral acidity) and normally after death the pH falls to around 5.5. When the pH stops falling, it reaches a value called ultimate pH (pHu), which is usually measured at about 24 hours after death. If less acid is produced, the pH does not fall as far and the pHu is higher than normal. A pHu above 5.8 is cause for concern because it indicates that a stressful event has occurred and it has profound effects on meat quality. Carcases with meat pHu values above 6 and as high as 7 indicate severe stress, under-nourishment and/or over-exercise.

There are many causes of livestock stress such as starvation, driving animals too hard, separating individuals from a group or mixing unfamiliar animals. These events can combine to affect its meat quality. If animals are driven long distances without rest, their energy stores will be significantly reduced. Normal livestock behaviour, such as fighting and rearing, can also burn up energy. Over use of electric prods, crowded transport conditions and being mustered too quickly are other examples of events that can stress animals and lead to high ultimate pH. We have observed pHu as high as 7 in animals that were emaciated due to poor nutrition (drought conditions) and once in a blind hind that was running the fences prior to slaughter. There are also reports of animals with grass staggers having high pHu. Ultimate pH can affect meat safety as well as colour, texture and processing quality, especially for vacuum packaged meat.

The main objections to high pHu meat are due to the dark colour and spoilage characteristics, but the consistency and eating quality are also considered objectionable. Meat with high pHu (> 6.0) has been found to have higher bacterial counts and approximately half the shelf-life than meat with normal pHu (5.5-5.7). The economic consequences are: (1) rejection of the product at various stages of the marketing chain; (2) cost of disposal of product and substituting normal meat; (3) loss of reputation for quality; and (4) down-grading of non-affected cuts. We have found a relationship between bruising and pHu, and often when the obvious portion of a bruise is cut away, the surrounding meat, although it may look normal, will have high pHu and will be of poorer quality.

Appearance

The appearance of meat is an extremely important factor in a customer's decision to purchase. Appearance relates to the meat's colour, colour stability (how fast it turns from red to brown), drip or purge, and presentation. On-farm factors such as stress can affect the meat pH which influences colour, colour stability and drip and purge, therefore it is important to minimise pre-slaughter stress. Bloodsplash or ecchymosis results in a bruised or speckled appearance with dark spots in the meat. This is believed to be related to stunning procedures and the time between stunning and sticking. Stress may also play a role in bloodsplash.

Other factors of processing, such as storage temperature and packaging, can also affect appearance. For example, vacuum packaging makes meat look darker and more purple and also can contain more purge or drip, which is unsightly and is often a very dark colour. Colour and purge or drip can be affected by vacuum packaging and storage conditions, particularly frozen versus chilled. Venison that has been frozen then allowed to thaw will be darker in colour than chilled venison, and have greater amounts of drip or purge, which is also darker in colour.

The colour of the background and the lighting can also affect presentation as will the presence of other meat that may have a redder colour. Venison has high iron content and is a darker red meat than most other species and this can be exacerbated by vacuum packaging. When venison is removed from a vacuum package, the meat "blooms" when the deoxygenated purple meat has access to oxygen and returns to its original redder colour. However, the longer venison has been in a vacuum package, the shorter the time after blooming that the colour is stable.

In studies with venison held at -1°C in a vacuum package, the number of days before the venison turned brown decreases with storage time as shown in table 2.

Table 2: Days of acceptable display colour at 1°C after storage at -1°C in a vacuum package.

No. of weeks at -1°C	No. of days acceptable colour
1	5
6	4
12	3
18	2

From: Seman *et al.*, 1988.

With each six weeks spent in a vacuum package in storage (often in transit), one day of retail display life is lost. Often after 18 weeks, when the packs are opened and steaks cut, they bloom up to a lovely red colour and then turn brown just a few hours later. When meat is held at 5°C, which is a much more common retail display temperature, the rate of colour change is about three times more rapid than it is at 1°C. At a display temperature of 5°C, the colour changes much more rapidly and venison turns brown much faster than other meats (Table 3).

Table 3: Days of acceptable display colour at 5°C.

SPECIES	No. of days acceptable colour
Venison	1.6
Lamb	3.1
Beef	4.7
Pork	5.7

From: Trout & Gutzke, 1995.

There is considerable variability in colour stability between animals, both in venison and other species. But with regard to venison, some animals have as little as a day good colour under the same conditions where average is about two days and some animals have up to eight days good colour. We are currently researching the mechanisms behind this and believe that we may be able to select for animals with premium colour stability, which is important for retail sale of venison. Colour is a very important attribute since consumers make their initial decision to buy a product based on appearance. But repeat purchase is generally based on palatability.

Palatability

Palatability is generally thought of in terms of tenderness, juiciness, flavour and texture and each of these attributes can be affected by a number of factors. Studies in other species have indicated that tenderness is the most important palatability attribute for acceptance of meat. Tenderness is affected by the growth rate of the animal, age of the animal, sex of the animal as well as the slaughter and processing protocols. Mature stags slaughtered after the rut are tougher than those slaughtered before the rut (Stevenson *et al.*, 1992), and toughness has been found to increase with animal age (Stevenson *et al.*, 1989).

Table 4 shows comparative tenderness data from longissimus dorsi (striploin or saddle) muscles over a range of age of red deer slaughtered in the same manner at a commercial slaughter plant in New Zealand. All carcasses were electrically stimulated since previous studies have shown that electrical stimulation ensures rapid tenderisation of carcasses (Drew *et al.*, 1988). Five animals were assessed in each age group for this study except for two year old stags where there were 15 animals (five light, medium and heavy weight two year olds were assessed and there was no significant difference in tenderness between the three weight groups).

Table 4: Tenderness change with animal age (means with standard deviations in brackets).

	Tenderness (kgF)	
Animal Age (years)	Stags	Hinds
1	4.7 (0.9)	4.0 (1.2)
2	4.7 (1.0)	3.9 (0.4)
3	5.0 (1.8)	4.0 (1.1)
5	6.5 (2.0)	4.6 (0.5)
>5	7.5 (3.4)	4.6 (0.6)

From: Stevenson *et al.*, 1989.

A tenderness or force score value of less than 5 kgF indicates very tender meat, values above 6 kgF indicate slightly to moderately tough meat and values above 8 kgF indicate very tough meat. This data indicates that as animal age increases, venison toughness increases, but much more so in the case of stags, and variability in tenderness increases. Therefore the farm management practices employed and the age at which animals are sent for slaughter can influence venison quality. The majority of animals slaughtered in New Zealand are killed before they are even two years old.

Recent evidence suggests that, as with other meat-producing animals, deer behaviour and pre-slaughter stress affect venison appearance, palatability and shelf-life. Animal behaviour and stress can affect the meat's ultimate pH (pHu), which influences tenderness. Normal pHu is around 5.5 and as pHu increases, toughness increases to a maximum around 6.0 as indicated in figure 1.

Beyond pHu 6.0, toughness decreases, but meat with pHu above 6.0 is darker in colour and has decreased shelf-life due to more rapid microbial spoilage. The toughness with intermediate pHu can be modified somewhat with conditioning and ageing of product (i.e. chilled storage), but even after 21 days chilled storage, intermediate pHu meat is still tougher than normal pHu meat. Often intermediate pHu meat (pH 5.8-6.2), even if it is from a young animal, will likely be much tougher than old stag meat. As mentioned previously, pH is

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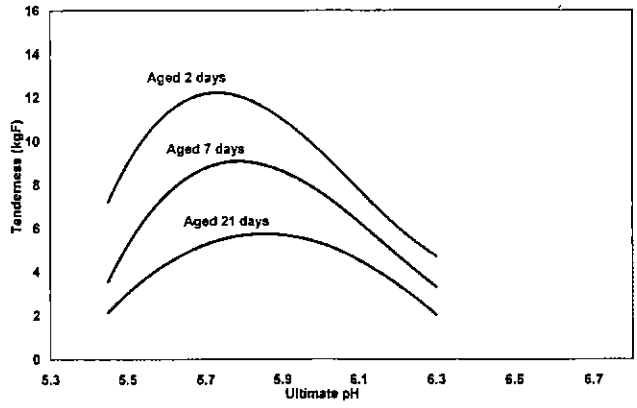
Figure1: The Effect of Ultimate pH on Venison Tenderness
(Data from striploins of 18 1-3 yr old red deer stags stored at 4 deg C)



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influenced by animal stress and farmers can contribute to venison quality by controlling and/or limiting the stressors. However, there is research in other animals that suggests that the animal's intrinsic behaviour may also play a role.

A very well-known animal researcher, Dr Temple Grandin, and her colleagues (Voisenet *et al.*, 1997a) have found that cattle with the most excitable temperament ratings produce carcasses with tougher meat and a higher incidence of intermediate pH than cattle with calm temperament ratings. In preliminary work with a group of 50 animals from Invermay, we found that two animals that were reported to be difficult to handle (flighty/skittery) also had correspondingly high pH. These observations suggest that selecting or culling based on temperament may be a good practice both from an animal handling and meat quality point of view. Selecting for temperament may also have additional benefits since other work by Voisinet *et al.*, (1997b) found that cattle with calm temperaments have higher average daily gains than cattle with excitable temperaments.

Although tenderness is the main palatability attribute of concern, juiciness, flavour and texture are also still important and can be affected by a number of factors. Research carried out in the 1970s at Invermay using deer up to 27 months of age found no significant differences in tenderness, juiciness, flavour or general acceptability between feral, grassfed and feedlot raised venison (Forss *et al.*, 1979). Research carried out in the 1980s with male and female red deer ranging from one to 13 years of age found no evidence that flavour varied with age although there were some flavour differences between males and females (Stevenson *et al.*, 1989). Somewhat unexpectedly, we found that females had more pronounced flavour intensity than males. This work also found no consistent juiciness differences between different sex and different age animals. However, we did find that texture altered with age, with meat from both stags and hinds over five years old having greater presence of resilient particles and/or fibres and lumpiness at the end of chewing than younger animals.

Juiciness can be affected by freezing and chilled meat is often perceived as having greater juiciness and a more succulent character than frozen meat. This is usually due to ice crystal damage causing more drip or purge from frozen meat and greater cooking losses, making it less juicy and making texture more sponge-like. These problems should not be present in meat that is frozen and thawed at proper temperatures. Freezing can sometimes affect the flavour if meat is not vacuum packaged and oxygen causes oxidation or rancidity, but our studies have found that vacuum packaged venison frozen at -12 or -18°C was of acceptable quality after two years of frozen storage (Stevenson *et al.*, 1984). Market reports indicate that customers perceive chilled venison to be a superior product to frozen and pay a premium for it.

Flavour can be affected by chilling conditions in two ways. Firstly, if carcasses are hung in warmer temperatures, stronger flavours can develop due to enzymatic reactions in the meat and bacterial spoilage. Secondly, long term chilled storage of up to 18 weeks in vacuum packages can lead to strong "off" flavours and odours which can be quite intense (Seman *et al.*, 1988). These are most likely the results of ingress of oxygen. Other meats often incur dairy or "cheesy" odours, which are attributed to proliferation of lactic acid bacteria, but venison does not appear to incur these odours. The meat pH can also affect juiciness, flavour and texture. Meat with high pH is reported to be less juicy, have objectionable flavours and a crumbly texture.