Beef Eating Quality
Summary of Good Practice
Control Point 1
Animal Input
- Genetics - Beef Sire
- Gender & status - Suckled heifers & steers

Control Point 2
Animal Management
- Feed - Grass/forage based, beneficial to assess vitamin & mineral levels in feed &/or stock- supplement as necessary.
- Growth rate - Consistent moderate growth rate (~ 0.8kg/d) from weaning with no major checks.
- Husbandry - Minimum stress- avoid vigorous exercise pre-slaughter
- Age - Preferably not over 26 months.
- Conformation and fat class - Minimum O+3 maximum 5L.
- Transport - Minimise stress - farm to abattoir, no mixing.
- Lairage - Minimise stress, slaughter on arrival or after a period of undisturbed rest.

Control Point 3
Early Post Mortem
- Carcase pH & Temperature; pH > 6.0 if temp > 35°C, pH < 6.0 before temp < 12°C.
- Stimulation – Electrical stimulation.
- Rigor – optimum 15°C
- Suspension – Hip suspension can benefit quality in loin and hindlimb muscles.

Control Point 4
Ageing
- Ageing - At least 7 days, tenderness can increase up to 21-35 days.
Control Point 1

Animal Input:
• Genetics - Between cross breeds, breed differences may be small and inconsistent (1-6). For example, it was shown that some sire breed differences exist for carcase traits, but sensory differences tend to be small, with carcases from Belgian Blue and Piedmontese sired steers giving a desirable combination of yield and palatability in loin, but carcases from Hereford-Angus cross steers giving a desirable combination of quality and palatability (2).

In pure bred animals, Aberdeen Angus have a significant tenderness advantage over Holstein (7). Breed differences appear to exist for marbling; Aberdeen Angus, Shorthorn and Hereford having higher marbling than Limousin, Simmental and Charolais (8). Certified Angus beef showed a significant tenderness and marbling benefit over USA Choice and Select beef (9-10).

The growth potential of the Sire does not impart eating quality benefits (11). Beef breeds have been reported to produce more tender meat when aged for less than 7 days compared to dual purpose and dairy breeds (12).

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• Gender and status - Bulls tend to produce tougher meat because they have greater collagen cross linking (13,14). If bulls are used then they should be suckled (15).

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• Handling & Stress - Careful management to reduce stress is very important and improves both productivity and welfare of cattle (16). Low stress is necessary to maintain muscle glycogen levels and hence meat quality. Stress (e.g. mixing, poor handling, unexpected loud noises, separation from the herd), can reduce muscle glycogen stores leading to a high ultimate pH and dark, firm, dry (DFD) meat (17). Where possible, if cattle are to be purchased and taken home, then they should be fully rested and integrated into their new surrounding (so as to ensure minimal impact of stress on muscle glycogen levels) before being taken for slaughter. If animals are stressed, it takes a minimum of 5 days to restore muscle glycogen levels once they have been used up (18). A period of 4 weeks between purchase and slaughter is recommended in Australia (18).

Physical damage to animals may appear as bruising on the carcase as well as potentially causing stress and leading to a loss of muscle glycogen and poorer meat quality.
• **Feed** - Diet has effects on flavour and may affect oxidative stability of meat, but has little or no effect on tenderness (19, 20, 35). However, the source of dietary fat and the level of antioxidant (e.g. Vitamin E) may be important. Beef from grass fed animals may develop off flavours more rapidly than beef from grain fed animals, and may develop fishy flavours during storage (20). Beef from grass/grass silage fed animals generally has better quality in terms of colour and lipid oxidation compared with beef from maize silage (21), or concentrate fed animals (22,23).

Vitamin E content of meat affects shelf life (24-26), there may also be flavour effects (27). Vitamin E is provided by grass so supplementation with Vitamin E may be needed with grain feeding. Addition of 2500mg Vitamin E to concentrate diets for 40d has been shown to give 7-10d extension in shelf life of meat (24), and supplements of 500-1000IU/head/d for 100-126d also provided antioxidant benefits for shelf life (25,26).

Feed can alter fatty acid composition, flavour and oxidative stability of meat (28,29). Forage based feeds tend to give higher levels of n-3 polyunsaturated fatty acids and Conjugated Linoleic Acid and lower saturated fatty acid concentration in beef (20,28-31). Linseed or sunflower oil containing diets may benefit n-3 and CLA levels (32, 33). Beef from pasture fed steers has a lower ratio of n-6/n-3 polyunsaturated fatty acids than beef from steers fed concentrates (34, 35).

Potato-processing waste or bread by-products can be used in finishing diets without reducing meat quality or animal performance (36,37).

• **Growth rate** – Consistent moderate growth rates from weaning appear important for good eating quality (20, 38-41). Continuous moderate growth at 0.7-0.8kg/d can give significant tenderness benefits at 14 d ageing (20). Periods of weight loss and backfat loss followed by weight and fat gain may impair quality and should be avoided (38). High growth rates do not necessarily benefit desirability (20) or quality (42). Compensatory growth – rapid growth after a period of restricted growth – does not generally benefit tenderness (8, 20, 43-47).

Small pre weaning variations in nutrition do not influence toughness at slaughter 10 months later (48). Feeding of high concentrate diets to early (103 d) weaned beef calves accelerates growth rate and fat deposition and gives good eating quality (49, 50). Autumn weaned calves may benefit from supplementary feeding with high protein pellets in winter-spring (51). Extensively produced young bulls may benefit from a minimum of 10 weeks finishing on concentrates (52).

• **Age** - Increasing age is associated with increasing toughness (13, 14, 53), but is also associated with flavour desirability (20). Collagen cross-linking increases and solubility decreases with age and maturity, which in part accounts for the observed increase toughness in older cattle. Overall the data would suggest that young cattle less than about 26 months old (14) (but younger than that for bulls (13)) are more likely to give tender meat. In a study of pure and crossbred Limousin steers it was found that tenderness decreased from ~ 15 to 18 months of age (54). Similarly increasing the age of slaughter from 16-18 to around 26 months of age may be associated with less tender beef for cattle finished on pasture (14). In USA and Australia there is a tendency to favour slaughtering animals between 14 and 17 months (55, 56) but this may be due to higher levels of concentrate/feedlot finishing.

Acceptable meat can be produced from young suckled bulls (<15 months old) (15, 57), intensively fed older bulls (19 months old) have increased fat content and muscularity but do not show sensory benefits (58).

• **Conformation and Fat class** - There is little specific information on conformation and fat class, but a minimum O+ 3 is widely adopted. Conformation does not directly link to eating quality, but muscular carcasses will reflect growth rate, the proportion of collagen may be lower and the level of cross-linking may be reduced, both of which can increase toughness (59). Subcutaneous fat may help to limit cold shortening, so over lean animals (<3) should be avoided. Intramuscular fat (minimum 4% in loin (60)) may benefit flavour (20) and juiciness (20) but over fat animals (>5H) should be avoided.

• **Transport** – Good handling of cattle is important to maintain eating quality (61). Animals should be subjected to minimum stress, no mixing of unfamiliar groups. High stocking density should be avoided (< 600kg/m2 (62)). Heifers in oestrus can cause stress by mounting activities, this will also increase the risk of bruising to the carcass.

• **Lairage** – Good handling to minimise stress in lairage is important. Cattle should be moved with minimum of force to help preserve muscle glycogen and limit the incidence of DFD. If possible animals should be slaughtered directly on arrival (63).
Control Point 3

Early post mortem:
- Carcase pH & temperature: The temperature and pH of the carcase have major impact on eating quality. The relationship between pH and temperature is very complex and involves the rate of fall of both parameters (64-66). The temperature of rigor onset can influence meat quality, if the temperature falls too rapidly the muscle will cold shorten and the meat will be tough, but if the cooling is too slow hot shortening can occur.

Considerate chilling can produce tender meat - the long standing premise is that no part of the carcase should be below 10°C within 10 hrs of slaughter (67). The rate of pH decline should not be too rapid in relation to carcase cooling (68). Most tender and least variable beef was shown to be in a pH range of 5.9 - 6.2 at 3hr post mortem (69). Meat with a high ultimate pH is tough. Very fast chilling (down to 0°C in the core by 5hrs after slaughter) can lead to tender meat (70), but results are inconsistent and cold shortening can occur.

Based on these data a general recommendation is pH > 6.0 if carcase temperature > 35°C, pH < 6.0 before carcase temperature < 12°C. It may be good practice to record both pH and temperature and adjust processing practices to meet optimum. Meat Standards Australia specifies that ‘the acceptable pH range is 5.30 to 5.70 for guaranteed eating quality’ (18).

- Stimulation – Electrical stimulation (ES) causes muscle contraction which uses up the muscle energy supplies (ATP and glycogen) and so accelerates pH fall and the onset of rigor and allows more rapid chilling. High voltage ES (HVES) increases tenderness in loin (55, 71-73). Low voltage ES (LVES) must be applied when the nervous system is intact; it tends to limit cold shortening but may induce hot shortening. ES will not work on DFD beef because of the low glycogen. The precise timing and nature of ES is very important. Different muscles will respond differently.

Electrical stimulation particularly at high frequency helps to control the pH fall and improves consistency of tenderness in loin, but had no effect in various other hind limb muscles (71). Improved tenderness is achieved within 24 hrs if HVES is used (72), the use of high voltage long duration ES produced lower shear force values in loin 75% of the time (73). However, although ES can significantly increase tenderness and flavour (74) it may reduce juiciness (20).

- Rigor - A rigor onset temperature of 15°C has greatest beneficial effects on tenderness (75). Rigor above 20°C will often lead to hot shortening.

- Suspension - The type of suspension used influences tenderness because muscle length appears to have a direct effect on meat tenderness. Loin tenderness depends largely on the extent of rigor shortening and post mortem proteolysis during refrigerated aging (18). Hip suspension improves tenderness in the loin and hindlimb muscles by imposing stretch throughout rigor. Stretching prior to aging can increase tenderness (75). Shear force values do not increase during rigor if the muscle is prevented from shortening (76, 77).

Control Point 4

Ageing:
- Ageing - Ageing is a major determinant of post mortem tenderness and affects flavour (20). Tenderness increases with time after 24 hrs and continues until around 21-35 days (78-80). Post mortem ageing is dependant on the activity of proteolytic enzymes which breakdown protein, the activity of these enzymes falls with time at 4°C (65, 81, 82). 80% of the tenderisation in beef occurs within 10d post slaughter at 1°C (83). Ageing for 14 days (84) may improve tenderness and flavour without increased risks of abnormal flavour.

During ageing, desirable ‘beefy, brothy and sweet’ flavours tend to decline whilst ‘bitter and sour’ flavours increase (20). For grass-fed, but not for grain–fed beef juiciness scores tend to increase during ageing up to 10d (20), but ground beef from feedlot cattle has been scored as considerably more juicy than that from pasture-finished cattle (20).

There is large variation in quality between and within muscles (85).The activity of the proteolytic enzymes varies between muscles (86-88) suggesting different ageing strategies should be used for different cuts and that loin cannot be regarded as indicative of carcase tenderness.
References

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