Meat quality of grain finished entire male *Bos indicus* cattle

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Abstract. Although the utilisation of young, entire male cattle for premium beef production is common in many parts of the world, it is not widely practiced in Australia. This study examined the carcass characteristics and eating quality of meat from entire *Bos indicus* males sourced from northern breeding herds and grain finished. Entire male calves were weighed and allocated to one of four (4) treatment groups: 1) Early-castrate (n=140); 2) Late-castrate (n=136); 3) Short-scrotum (n=121); 4) Entire (n=129). At ≈200 kg liveweight, all calves were weaned and those in Group 2 were castrated. The weaners were grown out on grass pasture to ≈330 kg liveweight, at which time they were sent to a feedlot and grain fed for 75 days, to ≈420 kg liveweight, prior to slaughter at 25 to 28 months of age. Data collected included carcass (weight, grade, gross value, butt shape, dentition, P8 fat depth, bruise score), MSA grading and meat quality data. Three muscles, eye round (*M. semitendinosus*), rump (*M. gluteus medius*) and striploin (*M. longissimus dorsi lumborum*) from thirty animals in each treatment group were used to generate consumer taste panel sensory test MQ4 scores. Carcasses from non-castrated animals that met the target AusMeat specification for "male" had a ≈$52 higher gross value than did those from castrated animals. Although meat from castrated animals had higher MQ4 scores than did meat from non-castrated animals, there were no differences between the boning groups for any of the sensory test outcomes, and, of the three muscles that were sensory tested, only striploins from early-castrated animals were rated as being of higher eating quality than striploins from late-castrate, short-scrotum or entire animals. Sensory test of meat quality as measured by MQ4 did not differ between carcasses of non-castrated animals that were graded as either "steer" or "bull" (43.862 ± 0.990 *vs* 45.078 ± 1.807, respectively; mean ± SEM), indicating that taste panels did not detect differences in the eating quality of the three muscles from these animals. This suggests that grading of carcasses of young animals on secondary sex characteristics may not accurately reflect the eating quality of meat from those carcasses. There were also significant disparities in the allocation of MSA star grades based on either MSA grading outcomes or taste panel sensory test results. Production of young entire *Bos indicus* males offers the potential for significant returns for northern beef producers with little impact to meat quality. However, there is a need for further data to be generated to allow the MSA grading model to be further refined for *Bos indicus* cattle.

Introduction

Each year some 8 – 10,000 young, entire male cattle are sent to slaughter from breeding properties in northern Australia (McDonald *pers comm.*). Beef from entire males, "bull beef", has traditionally been a by-product of cow/calf breeding operations or the dairy industry, despite evidence suggesting that beef enterprises can benefit from the highly efficient fast growing characteristics of entire male cattle that achieve target weights earlier (Nichols *et al.* 1963; Bailey *et al.* 1966; Seideman *et al.* 1982). Previous MLA funded projects have demonstrated significant productivity gains in entire male cattle (Ridley and Schatz 2006). The results showed that, in comparison to Brahman steers when slaughtered at the same fatness, Brahman bulls had a 15% advantage in carcass weight.

There is an ever growing body of international evidence that supports the concept of producing lean beef from entire males with the animal welfare benefits arising from the elimination of castration from the production system. Some live export markets actually pay a premium for entire males but in the local domestic trade, however, entire male cattle historically receive a heavy discount because of the perception of poorer meat quality. This perception may be attributed to the knowledge that the majority of beef produced from entire males in Australia is a product of cast for age bulls, rather than young animals.

There is significant potential for young, entire male cattle from northern breeding properties to be value-added through grain-finishing, however, consumer perceptions of the eating quality of beef from entire young *Bos indicus* need to be evaluated and addressed. In addition, there are substantial animal welfare benefits to be gained if castration of these animals is avoided.

The objectives of this study were to evaluate carcass yield and quality, and consumer eating quality characteristics of young short-scrotum and entire male cattle finished on grain for the domestic trade compared with early- and late-castrated males.

Methods

This study was conducted under JCU Animal Ethics Committee Approval no. A1342, in collaboration with McDonald Holdings Pty Ltd (MDH) on a number of their properties. The cattle used in the study were bred on *Rutland Plains* (15° 38.804'S 141° 50.800'E) and *Dunbar* (16° 2.852'S 142° 23.644'E) in the eastern Gulf of Carpentaria/western Cape York region, grown out on pasture at *Devoncourt*, Cloncurry (21° 12.937'S 140° 13.958'E), and finished on grain to Domestic Trade Steer specifications at MDH's *Wallumba* feedlot (26° 50.646'S 150° 14.173'E) on the Darling Downs.

Experimental design

The study was conducted in an experimental design incorporating four (4) male treatments. In the second mustering round at *Rutland Plains* and *Dunbar*, entire male calves were weighed and allocated at random to one of four (4) treatment groups, as follows: 1) Early-castrate: surgically castrated at 1 to 4 months of age; 2) Late-castrate: castrated at weaning at ≈200 kg liveweight (≈9 to 12 months of age); 3) Short-scrotum: underwent a rubber banding procedure at 1 to 4 months of age to produce short-scrotum entire males (artificial cryptorchid); 4) Entire: remained intact for the duration of the experiment.

At ≈9 to 12 months of age (≈200 kg liveweight), all calves were weaned and relocated to *Devoncourt*, where those calves in Group 2 (Late-castrate) were castrated. All the weaners were grown out on *Devoncourt* to ≈330 kg liveweight, at which time they were sent to *Wallumbah* feedlot and grain fed for 75 days, to ≈420 kg liveweight. On exiting the feedlot (25 to 28 months of age), all animals were sent for slaughter at JBS Australia's Dinmore abattoir (JBS) (see Table 1).

Data collection

Carcass grading data from vendor feedback sheets. The vendor feedback sheets provided data on carcass Sex (M = male, B = bull), Dentition (number of permanent incisors), Hot Carcass Weight (kg) and Gross Value ($); and for each side – P8 Fat Depth (mm), Butt Shape (A to E, with A being most convex and E being most concave.), Hot Weight (kg), Bruise score (1-9 depending on the position of the score-able bruise), Grade, $/kg.

MSA carcass evaluation. The MSA grading model assigns one of four eating quality grades (2-star = unsatisfactory, 3-star = "good every day", 4-star = "better than everyday", or 5-star = "premium") to 40 individual carcass muscles cooked by up to six alternative methods. The grade is assigned by a statistical prediction model which estimates a predicted meat quality (PMQ) score on a 0 – 100 scale for each muscle x cook outcome, based on inputs of % *Bos indicus*, sex, carcass weight, ossification, marbling, rib fat, carcass suspension method, ultimate pH, and meat colour (Watson *et al.* 2008). The current PMQ cut-offs for 3-star, 4-star and 5-star are 46.5-63.9, 64.0-76.9 and 77.0-100.0 points, respectively (Watson *et al. 2008*). For MSA grading purposes, all the project cattle were a high grade Brahman genotype and so were classed as being 100% *Bos indicus.* All were hung by the achilles tendon during the slaughter process and entered in the MSA grading model as steers.

Table 1. Number of cattle either castrated at branding (Early-castrate), castrated at weaning (Late-castrate), banded to create an artificial cryptorchid (Short-scrotum) or left intact (Entire).

	Early-castrate	Late-castrate	Short-scrotum	Entire	Total
Allocated to the project (Sept/Oct 2008)	169	170	161	165	665
Relocated to *Devoncourt* at weaning (July – Oct 2009	≈147	≈151	≈133	≈140	≈571
Inducted into *Wallumba* feedlot (16 July 2010)	142	136	121	129	528
Slaughtered at JBS, Dinmore (23 Sept 2010)	140	136	121	129	526

Assessment of meat quality. Forty animals from each treatment group were initially allocated for evaluation of meat quality, from which 30 animals were selected for further meat quality and sensory testing following MSA carcass evaluation. Three muscles, eye round (*M. semitendinosus* - EYE), rump (*M. gluteus medius* - RMP) and striploin (*M. longissimus dorsi lumborum* - STR), aged either 7 days or 35 days (15 each) were used to evaluate shear force (Geesink *et al.* 2011).

Sensory testing. The sensory testing of three muscles from each of the treatment groups was carried out by Meat Standards Australia using standard protocols and the grilling cook method (Watson *et al.* 2008). In brief, each sample was evaluated by 10 consumers for tenderness, juiciness, flavour and overall liking. Additionally, consumers assessed the star-rating (satisfaction) for each sample. A trimmed mean was used to give a robust and reasonably reliable measure, MQ4. This measure forms the basis of the MSA consumer prediction model, which generates a predicted MQ4 (PMQ4) from available data and is considered to be a good assessment of the consumer assessment of meat eating quality (Watson *et al. 2008*).

Statistical analyses

Predicted meat quality (PMQ) data. All carcass quality and sensory data were analysed using a REML model in GenStat (GenStat 2011) with animal ID as the random effect and treatment Group, Muscle and Aging as categorical variables.

MSA star grade. For muscles animals that were selected for taste panel sensory testing, MSA Star-grades were determined either from the boning group data derived from MSA carcass grading (MSA1-BG), the PMQ data generated by the MSA Model (MSA2-PMQ), or from the MQ4 data derived from sensory testing (MSA3-MQ4). McNemar's test (GenStat 2011), was used to test whether one grading system was more likely to give a grade of 3-star or better, compared to the other.

Results

Carcass grading data from vendor feedback sheets

About 30% of the carcasses from non-castrated animals were graded as "bull" following slaughter, compared with less that 1% of carcasses from castrated animals (Table 2).

Table 2. Numbers of carcasses (proportions in brackets) by treatment group that were classified as either male or bull, based on the presence or absence of secondary sex characteristics.

Treatment group	N	Male	Bull
Early-castrate	140	139 (99.3)^{a}	1 (0.7)
Late-castrate	136	135 (99.3)^{a}	1 (0.7)
Short-scrotum	121	87 (72.1)^{b}	34 (27.9)
Entire	129	87 (72.5)^{b}	43 (27.5)

a, b – Column means with unlike superscripts differ, P<0.001

Castrated animals had lower hot carcass weights than non-castrated animals (P<0.001). For Early-castrate *vs* Late-castrate and Short-scrotum *vs* Entire, hot carcass weights did not differ (Table 3).

There was an association (P<0.05) between sex (Male – castrated or entire animals not showing secondary sex characteristics; and Bull – animals showing secondary sex characteristics) and dentition (Table 4). 87% of animals that graded as "Bull" had two or more permanent incisors compared with 70% of animals graded as "Male", accordingly, 15% of animals that graded as "Bull" had at least four permanent incisors compared with only 9% of animals that graded as "Male" (Table 4). Animals that graded as "Bull" had greater Hot Carcass Weights (P<0.05) than those graded as "Male" (257.7 ± 2.7 kg *vs* 229.0 ± 1.3 kg, respectively). There were no differences among treatment groups for bruising (only two carcasses were trimmed for bruising).

Table 3. Hot carcass weights and gross carcass values by treatment group.

Treatment group	N	Hot carcass weight (kg)	Gross carcass value ($)
Early-castrate	140	226.24 ± 2.49[a]	737.88 ± 12.27
Late-castrate	136	224.09 ± 2.19[a]	725.03 ± 12.68
Short-scrotum	121	242.49 ± 2.66[b]	744.75 ± 12.70
Entire	129	242.09 ± 2.26[b]	737.65 ± 10.40

a, b – Column means with unlike superscripts differ, P<0.001

Table 4. Numbers of animals with permanent incisors (either 0, 2, 4 or 6), either classed as "Male" (no secondary sex characteristics) or "Bull" (secondary sex characteristics).

Sex	Dentition (No. of permanent incisors)				
	0	2	4	6	All
Bull	10	57	11	1	79
Male	133	275	39	0	447
All	143	332	50	1	526

Gross returns. Hot carcass weights, P8 fat depth and gross carcass value stratified by Male or Bull classification and treatment Group are presented in Table 5. Of 526 animals killed, 79 graded "Bull"; these also represented the heaviest carcasses with the lowest fat scores. Carcasses from non-castrated animals that graded "male" had a ≈$52 higher gross value than did those from castrated animals (P<0.05), while carcasses from non-castrated animals that graded "bull" had a ≈$83 lower gross value than those from castrated animals (P<0.05), and a ≈$137 lower gross value than those from non-castrated animals that graded "male" (P<0.05). As such, the average gross value of the carcasses did not differ between the treatment groups (Table 3).

Chiller assessment and MSA grading

There were no differences among treatment groups for meat colour (MC) or fat colour (FC) scores. Carcasses from Entire animals had slower pH declines (P<0.05) than those from non-castrated animals, however, there were no differences among treatment groups for ultimate pH.

Ossification. Castrated animals had lower (P<0.001) ossification scores than non-animals (≈138 *vs* ≈156, respectively), and carcasses graded as "Male" had lower (P<0.001) ossification scores than those animals graded "Bull" (≈144 *vs* ≈165, respectively).

AusMeat and USDA marbling scores. There were no differences between the treatment groups for AusMeat marbling scores, however, castrated animals had higher USDA marbling scores (P<0.05) than non-castrated animals (228.36 ± 3.94 *vs* 204.54 ± 3.94, respectively).

Rib fat score. Castrated animals had greater rib fat (P<0.05) values and smaller (P<0.05) eye muscle area than non-castrated animals (≈4.65 mm *vs* ≈3.50 mm and ≈65.5 cm^2 *vs* ≈68.0 cm^2, respectively).

Hump height. Castrated animals had lower hump heights (P<0.05) than non-castrated animals (≈132 mm *vs* ≈153 mm, respectively).

Boning groups and non-compliance with MSA standards. Carcass parameters by boning group are presented in Table 6. No carcasses qualified for MSA boning groups 1 through 5; and a greater number of carcasses from castrated animals were allocated to boning groups 6 to 10 (P<0.05), compared to those from non-castrated animals. The most common reason for non-compliance or ungraded carcasses was due to insufficient fat cover - 14% of castrated animals versus 31% of non-castrated animals. Carcasses allocated to boning groups 6 through 10 had significantly less hump height, greater rib fat values, greater USDA marbling values, and tended to have lighter muscle colour than animals allocated to boning groups >10. Carcasses allocated boning groups >10 had greater eye muscle area (P<0.05). Fat colour scores did not differ between the boning groups.

Table 5. Hot carcass weights, P8 fat depth and gross values (mean ± SEM) of carcasses from animals graded as "male" or "bull", by treatment group.

Grade	Treatment group	N	Hot carcass weight Kg	P8 fat depth Mm	Gross value $
For carcasses graded "male"	Early-castrate	139	225.61±2.43^a	11.99±0.35^a	737.27±12.34^a
	Late-castrate	135	223.97±2.20^a	11.77±0.33^a	726.16±12.73^a
	Short-scrotum	87	236.61±3.05^b	9.76±0.32^b	783.94±14.75^b
	Entire	87	234.80±2.66^b	10.31±0.35^b	780.62±12.09^b
For carcasses graded "bull"	Early-castrate	1	314.00	6.00	822.68
	Late-castrate	1	240.50	8.00	573.72
	Short-scrotum	34	257.10±4.47^c	8.63±0.36^c	647.34±15.56^c
	Entire	42	257.18±3.16^c	8.36±0.48^c	648.65±10.74^c

a, b, c - column means with unlike superscripts differ, P<0.05

Predicted meat quality (PMQ) scores and meat quality test results. Castrated animals had greater PMQ scores (P<0.001) than did uncastrated animals (≈48.0 *vs* ≈46.0, respectively). Striploins from castrated animals had lower shear force (P<0.001) than those from non-castrated animals (≈4.4 kg vs ≈5.3 kg, respectively). Shear force test for eye rounds and rumps did not differ among the treatment groups. Ageing from 7 days to 35 days reduced (P<0.001) shear force for striploins from Entire animals (≈6.1 kg vs ≈5.0 kg, respectively).

Sensory testing

MQ4 score. In general, additional aging from 7 to 35 days resulted in improved MQ4 scores. For striploins only, Early-castrate animals had higher MQ4 scores than Late-castrate, Short-scrotum or Entire animals, which did not differ (53.11 ± 2.6 *vs* 47.73 ± 2.52, 45.73 ± 2.89 and 41.50 ± 2.53, respectively, P<0.01).

Boning groups. There were no differences between carcasses assigned to boning groups 6 through 10 and those >10 for any of the sensory outcomes. MQ4 scores for muscles from castrated animals were greater (P<0.01) than those from non-castrated animals graded as either "Male" or "Bull", which did not differ from each other (see Table 6).

Table 6. MQ4 from sensory testing of 3 muscles x 2 ages for animals either castrated or entire , and graded as either "male" or "bull".

Treatment group	N	MQ4		
		Mean ± SEM	Median	95% CI
Castrated	179	47.319 ± 0.923[a]	48.483	45.497 – 49.141
Entire – graded as "male"	137	43.862 ± 0.990[b]	44.067	41.905 – 45.819
Entire - graded as "bull"	36	45.078 ± 1.807[b]	44.425	41.410 – 48.747

a, b – Column means with unlike superscripts differ, P<0.01

Table 7. Proportions of two muscles, rump (RMP) and striploin (STR), graded as MSA 3-star by protocol MSA1-BG, MSA2-PMQ or MSA3-MQ4.

Protocol	RMP (% MSA 3-star)	STR (% MSA 3-star)
MSA1-BG	39.2[a]	33.3[a]
MSA2-PMQ	95.0[b]	60.0[b]
MSA3-MQ4	56.3[c]	67.5[b]

a, b - Percentages within a column with unlike superscripts differ, P<0.05

Discussion

Table 5 clearly illustrates the premium that can be achieved by marketing young entire male cattle that achieve a specific target of beef cattle AusMeat grade on a meatworks grid. The cattle in the present study were sold as AusMeat Grain Fed Young Beef (GFYG), for which animals may be female, castrate or entire males that show no secondary sex characteristics. Carcasses from non-castrated animals that met the GFYG specification had a ≈$52 higher gross value than those from castrated animals, while carcasses from non-castrated animals that were graded "bull" because of secondary sex characteristics had a ≈$83 lower gross value than those from castrated animals, and a ≈$137 lower gross value than those from non-castrated animals that graded GFYG.

Gross return

The mean gross return of the carcasses did not differ between the treatment groups. The lower returns from non-castrated animals that were down-graded as "bull" were countered by the greater carcass weights and premiums achieved for the non-castrated animals that graded "steer" (see Table 3)

Chiller assessment and MSA grading

Interestingly, "dark-cutters" are generally mentioned in any discussion of the utilisation of young entire male cattle for beef production. Early-castrates, Late-castrates, Short-scrotum and Entire treatment groups had 4, 1, 0 and 5 carcasses classified as dark-cutters, suggesting that there was no difference in the incidence of dark-cutters between castrates and non-castrates. Although there were differences in the rate of pH decline, there were no differences in ultimate pH, demonstrating that proper nutritional management and minimised sorting or mixing throughout the growing and finishing stages can help to minimise the incidence of dark-cutters.

Ossification and dentition. Ossification was positively correlated with dentition, and while there were no differences in dentition between the treatment groups, castrated animals had lower ossification scores than did non-castrated animals, indicating that although the treatment groups were of similar mean calendar age, non-castrated animals were physiologically older than castrated animals. Although significant, the difference was not great. In the MSA model, for 100% *Bos indicus* cattle, a 10 point increase in ossification score leads to a 1 point decrease in PMQ4 score, for grilled striploin aged for 7 days (Geesink G, *pers comm.*). This supports the conclusion that entire animals should be finished at a younger age than their castrated equivalents, in order to minimise the chance of downgrades.

Hump height and eye muscle area. That castrated animals had lower hump heights than did non-castrated animals suggests that in this case, given that all of the project cattle were high-grade Brahmans, hump height may be more a reflection of testosterone levels than percentage of *Bos indicus* in the cattle. Similarly, eye muscle area was mirrored in the hot carcass weight. Non-castrated animals had greater hot carcass weights and eye muscle areas than did castrated animals, reflecting the anabolic effects of testosterone levels in the non-castrated animals.

Predicted Meat Quality score. Although the current MSA model is not validated for non-castrated animals, inputs into the model other than castration status (ossification, marbling score and rib fat) resulted in castrated animals having higher PMQ scores than non-castrated animals.

Meat quality test results

Shear force. For striploins only, there was a difference in shear force for castrated *vs* non-castrated animals, with the latter having higher shear force test. This result is broadly reflected in the sensory test MQ4 outcomes, with lower shear force scores being indicative of more tender meat, and is consistent with the status of striploin as being of superior quality to the other two muscles tested (Watson *et al.* 2008).

Sensory testing

MQ4. Only striploins from Early-castrate animals had higher MQ4 scores than did striploins from Late-castrate, Short-scrotum or Entire animals. Of the three muscles used for sensory testing, grilled striploins would be expected to be of the highest meat quality score (Watson *et al.* 2008), and therefore are likely to be the most sensitive indicator of treatment effects. The increased eating quality due to ageing from 7 days to 35 days is well documented (Watson *et al.* 2008).

Boning groups. That there were no differences between the boning groups for any of the sensory test outcomes, for rumps and striploins in particular, is surprising and indicates that for high-grade *Bos indicus* cattle at least, taste panels were not able to detect differences in eating quality of some muscles. This finding supports the view that there is a need for further data to be generated to allow the MSA grading model to be further refined for *Bos indicus* cattle.

Sensory testing versus AusMeat carcass grade. Sensory test of meat quality as measured by MQ4 did not differ between carcasses of non-castrated animals that were graded as either "steer" or "bull" (43.862 ± 0.990 *vs* 45.078 ± 1.807, respectively; mean ± SEM), indicating that taste panels did not detect differences in the eating quality of the three muscles from these animals (see Table 7). This suggests that grading of carcasses of young animals on secondary sex characteristics may not accurately reflect the eating quality of meat from those carcasses. Muscles from castrated animals had a higher mean MQ4 score (47.319 ± 0.923; mean ± SEM), indicating that, on average, taste panels judged those muscles to be of slightly higher eating quality.

MSA Star grades

For the three of the muscles that were sensory tested, there were significant disparities in the allocation of MSA star grades based on either boning groups (MSA1-BG), predicted meat quality scores (MSA2-PMQ) or taste panel sensory test results (MSA3-MQ4) (see Table 7). For striploins and rumps, in particular, the disparities in the allocation of MSA star grades based on either boning groups (MSA1-BG), predicted meat quality scores (MSA2-PMQ) or taste panel sensory test results (MSA3-MQ4), appear to be more than one might expect from a grading system designed to ensure that the consumer does not have an unacceptable eating experience from consumption of beef of

MSA 3-star quality or better. This represents a significant potential financial loss for producers targeting the premium available for MSA graded carcasses, as animals that would have provided an MSA 3-star "good every day" eating experience, at least for those muscles, are being incorrectly "ungraded" for MSA.

Production of young entire *Bos indicus* males offers the potential for significant returns for northern beef producers with little impact to meat quality. However, there is a need for further data to be generated to allow the MSA grading model to be further refined for *Bos indicus* cattle.

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