Consumer Topics

DOES VARIATION BETWEEN MUSCLES IN SENSORY TRAITS PRECLUDE CARCASS GRADING AS A USEFUL TOOL FOR CONSUMERS?

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Introduction

While the original purpose of carcass grading or description systems may have been to sort carcasses into groups of like appearance or composition they are often assumed to also convey meaningful statements in regard to palatability levels as assessed by consumers. Presumably few consumers would believe that all carcass portions have equal palatability but there appears to be an underlying assumption that the cuts have some form of reliable palatability relationship. A ‘good cook’ or astute consumer is presumed to understand this basic relationship along with cut by cut cooking effects in order to produce beef meals of a consistent expected quality.

A sizeable proportion of meat science literature is devoted to studies of the *m.longissimus lumborum* (LD) muscle with corresponding detailed knowledge of other muscles or positions within muscles sparse in comparison. In both commercial grading and many scientific studies the underlying assumption is that the striploin cut (LD) is a suitable reference point for describing carcasses in total and also their component cuts or muscles. Both subjective and objective approaches assess the LD as a base for sorting carcasses into groups, assumed to correspond to palatability thresholds or ranges.

This paper challenges these assumptions using Meat Standards Australia (MSA) findings. These findings are based on extensive consumer testing of muscles subject to a wide range of animal variables, processing treatments and multiple cooking methods. It is contended that while relationships between muscles can be defined, they differ widely in response to a number of factors which interact, creating considerably different relative outcomes. To more accurately assess palatability the causative relationships or available grading inputs need to be weighted or combined differently on a muscle by muscle basis.

While extensive consumer testing can quantify these relationships and produce useful consumer predictions (Watson *et al*. (2005)) this is an expensive process and does not provide direct explanation of mechanisms involved. If the mechanisms were better understood it might be possible to more effectively predict individual muscle consumer outcomes, reducing the need for extensive consumer testing.

There is a need for more comprehensive study of muscles other than the LD to categorise compositional and mechanistic effects which could be effectively used to predict consumer satisfaction from each portion of any beef carcass.

Objectives

The objective of this study was to examine the degree to which a predicted consumer score for the anterior portion of the LD muscle remained constant as a ratio to those for other muscles over a range of production, processing and cooking scenarios.

Methodology

The MSA 2004 prediction model was used to predict consumer based MQ4 scores for muscles from a range of carcasses. The MQ4 score is a composite score created by weighting and combining consumer scores for tenderness, flavour, juiciness and overall satisfaction. The prediction process is described by Watson (2005) and development of the MQ4 score consumer testing methodology further described in Watson *et al*. (2005). The model provides a useful prediction of consumer responses to over 35,000 cuts tested within the MSA program over a ten year period utilising five cooking methods and involving in excess of 65,000 consumers.

The model was run for a series of alternative inputs and ratios calculated between the anterior grilled striploin (*m.longissimus lumborum*) MQ4 score of each carcass relative to the MQ4 score of other muscles. Muscles reported are *mm. adductor femoris* (AF), the cranial and distal portions of the *biceps femoris (syn. Gluteobiceps)* (BFC and BFD), *gluteus medius*, divided between the "eye" (GME) and "D" (GMD) positions, *infraspinatus* (IF), *psoas major* (PM), *rectus femoris* (RF), *semimembranosus* (SM), *semitendinosus* (ST), *serratus ventralis cervicis* (SV), *spinalis dorsi* (SD), *triceps brachii caput longum* (TB), *and vastus lateralis* (VL). These muscles were selected to represent major commercial cuts.

An achilles hung, non-implanted steer carcass of 0% *bos indicus* content, 250kg carcass weight, 150 ossification, 250 marbling with an ultimate pH of 5.5 @ 3.0°C with all cuts aged seven days post slaughter was selected as a base example. The ratio of predicted MQ4 scores for a range of cuts and cooking method combinations from this carcass are presented in Table 1.

Table 1. Ratio of cut by cook MQ4 scores for selected muscles (Base carcass)

MUSCLE	Code	Grill	Roast	Stir Fry	Thin Slice	Slow Cook
m.longissimus lumborum	**LD**	100	101	104	105	na
m.spinalis dorsi	**SD**	136	118	135	128	na
m.psoas major	**PM**	136	134	140	130	na
m.infraspinatus	**IF**	113	109	118	123	na
m.triceps brachii caput longum	**TB**	96	102	104	106	107
m.gluteus medius ("D")	**GMD**	90	105	99	109	95
m.gluteus medius (eye)	**GME**	95	109	108	107	na
m.biceps femoris (cap)	**BFC**	104	na	118	119	na
m.biceps femoris (distal)	**BFD**	na	71	75	98	103
m.rectus femoris	**RF**	83	106	97	103	84
m.vastus lateralis	**VL**	65	85	79	91	93
m.semitendinosus	**ST**	77	84	80	85	88
m.adductor femoris	**AF**	71	na	91	95	89
m.semimembranosus	**SM**	62	77	77	100	93
m.serratus ventralis cervicis	**SV**	95	97	98	104	118

Subsequent predictions were run for carcasses with amended *bos indicus* content, differing ossification, sex and marbling scores, implanted with hormone growth promotants (HGP), suspended by the aitch bone and aged for differing periods. Ratios were recalculated for the selected muscles within each carcass specification in relation to the grilled LD, the score for which was set to 100 in each case.

Results & Discussion

Results are discussed in relation to the efficacy of an anterior grilled striploin MQ4 score as a basis for grading other commercially significant carcass muscles. It is assumed that the objective of grading is to provide an accurate estimate of consumer satisfaction in relation to the final cooked product.

As shown in Table 1 the MQ4 ratios vary extensively between muscles, between cooking methods and for position within some muscles. While there is little ratio difference between cooking methods for the LD extreme differences are evident in the VL, BFD and SM and moderate differences in the GMD, GME, RF, AF and SV. The consumer is predicted to obtain a superior result by roasting the GMD, GME, RF, VL and SM in comparison to grilling. The SV records its best result slow cooked in contrast to the SM which is best thin sliced. Within muscle position differences are also predicted for the GMD versus GME and for the BFC in comparison to the BFD.

Koohmaraie *et al* (2002) have stated that beef tenderness can be explained by the cumulative effects of sarcomere length, connective tissue toughness and proteolysis in individual muscles. It would be advantageous to reduce the requirement for extensive consumer testing by applying more detailed knowledge of the relative importance, action and interaction of these three factors on an individual muscle or muscle by position basis. If the ratios displayed between the grilled LD and other muscle by cook combinations were consistent then it follows that detailed experimental results from the LD could be used to predict the balance of the carcass. This reflects the base assumption of carcass grading.

However, as demonstrated by Table 2, this assumption is seriously flawed. The calculated ratios (for grills only), displayed for the base and 7 alternative carcasses, differ widely. As an example the SD MQ4 score has a ratio of 136 to the LD in the base carcass but ranges from 112 in carcass C to 171 in carcass A due to the calculated model interactions. While the SD ratios are similar for the base and carcass B, and while carcasses D and F, and E and G are similar to each other the SD ratios differ widely between pairs.

Table 2. The ratio of predicted MQ4 scores (Grill) for selected muscles from a range of carcasses.
** AT=achilles tendon, TX=obturator foramen

MODEL INPUTS		CARCASS INPUTS							
		Base	A	B	C	D	E	F	G
% bos indicus		0	100	0	0	60	35	0	60
Sex		M	F	M	M	M	F	M	M
HGP implant		No	No	Yes	No	No	No	No	Yes
Carcass Wt (Kg)		250	250	380	280	290	250	380	290
HANG **		AT	AT	AT	TX	TX	AT	AT	AT
Ossification		150	120	170	120	170	500	190	190
Marbling		250	200	330	350	330	200	500	300
Rib fat (mm)		5	5	5	5	5	5	15	5
pHU		5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
Loin temp°C		3	3	3	3	3	3	3	3
Days aged		7	7	14	21	14	28	14	21
MUSCLES	**CODE**	**RATIO TO LD MQ4**							
m.longissimus lumborum	**LD**	100	100	100	100	100	100	100	100
m.spinalis dorsi	**SD**	136	171	134	112	124	147	121	143
m.psoas major	**PM**	136	162	134	114	125	144	122	142
m.infraspinatus	**IF**	113	142	110	91	99	120	100	114
m.triceps brachii caput longum	**TB**	96	114	95	84	85	87	87	95
m.gluteus medius ("D")	**GMD**	90	121	89	90	95	92	82	95
m.gluteus medius (eye)	**GME**	95	128	94	94	100	98	87	101
m.biceps femoris (cap)	**BFC**	104	139	101	96	102	106	94	109
m.rectus femoris	**RF**	83	104	83	79	84	77	77	85
m.vastus lateralis	**VL**	65	80	66	65	67	56	61	66
m.semitendinosus	**ST**	77	98	79	72	71	63	72	80
m.adductor femoris	**AF**	71	88	70	72	78	70	68	74
m.semimembranosus	**SM**	62	77	62	65	70	60	60	65
m.serratus ventralis cervicis	**SV**	95	117	96	83	86	97	89	97

Alternative muscles display further range differences and the pairings described above also differ. While the base carcass and B share equal ratios between their LD and RF, and similar ratios for most muscles, the RF ratios differ widely between pairs D and F and E and G which were previously paired by their SD ratios.

This pattern of irregular association is seen across the range of cuts within each carcass and reflects the differential effect of various model inputs on predicted consumer scores for each muscle. Input differences, shown in the upper portion of Table 2, were from 0 to 100% bos indicus content, male versus female, implanted (HGP) or not, achilles tendon (AT) or obturator foramen (TX) suspension and a range of carcass weights, ossification and marbling scores, together with variation in ageing. Within each of the carcasses any change to the ageing period would produce further substantial changes in ratios as muscles age at different rates and ageing further interacts with carcass suspension. (Watson. 2005)

While sarcomere length, connective tissue toughness and proteolysis might explain all tenderness differences, the large ratio differences within the example carcasses in table 2 suggest that if this is so these causative factors are in turn affected differentially by mechanical effects including carcass suspension, by biological effects such as sex, HGP implant use and ossification level, and by directly observed muscle characteristics such as marbling and pH. Consequently relative muscle palatability is not fixed, but varies widely and individually in response to other influences. These influences may act by modifying sarcomere length, connective tissue toughness and proteolysis individually or by interaction.

The MSA prediction model is effective due to its development from extensive consumer testing. This is an expensive process if a large number of potential individual muscle effects and interactions must be tested to develop predictions. The ideal approach is to combine knowledge of muscle composition, characteristics and causative mechanisms to accurately predict the performance of all commercially important muscles without the requirement of blanket consumer testing. At present the literature is dominated by LD data which does not adequately relate to other muscles. More research is required on alternative muscles to build an adequate knowledge base to facilitate eating quality prediction.

In recent studies National Cattlemens Beef Association (2000) presented data on a number of chuck and round muscles while Rhee *et al*. (2004) have reported extensive data on major muscles which will assist in developing the required knowledge. Further studies and collaboration are needed to estimate the relative impact of sarcomere length, connective tissue toughness and proteolysis in individual muscles and to more adequately describe relationships between these factors and the mechanical or biological mechanisms which modify their influence.

A suitable prediction regime developed from improved data might provide a basis for estimation of consumer satisfaction and allow consumer testing to be used as a validation tool rather than as a means of obtaining primary data.

Conclusions

The analysis conducted demonstrates that it is not possible to provide meaningful estimates of consumer satisfaction for a range of cuts from a simple LD relationship. The relationship between muscles varies extensively depending on a range of inputs including the period of ageing, carcass suspension, cooking method, % bos indicus, marbling, ossification, sex, carcass weight and use of hormonal growth promotants.

The implication is that for grading systems to be useful to consumers they need to independently estimate specific muscle results. This challenges the notion of grading a carcass as a single unit. While a common set of grading inputs may be appropriate they need to be applied differentially by muscle to adequately estimate eating quality. This implies a need to modify thinking from grading carcasses to grading individual cuts.

A related caution is raised regarding attempts to interpolate objective LD based experimental results to other carcass muscles. Further studies and collaboration are needed to estimate the relative impact of sarcomere length, connective tissue toughness and proteolysis in individual muscles and to more adequately describe relationships between these factors and the mechanical or biological mechanisms which modify their influence.

A suitable prediction regime developed from improved data might provide a basis for estimation of consumer satisfaction and allow consumer testing to be used as a validation tool rather than as a means of obtaining primary data.

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