Meat quality in beef heifers slaughtered at oestrus

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Introduction

Dark-cutting in beef is a meat quality defect which is estimated to occur in one to five percent of prime heifer and steer carcasses. It is characterised by a high meat ultimate pH, giving rise to an abnormally dark colour, lower eating quality and reduced shelf-life of the product (Hood and Tarrant, 1981). The pH of meat is determined by the glycogen content of the muscles at slaughter.

Dark-cutting is associated with the level of mounting activity in groups of young bulls mixed prior to slaughter (Kenny and Tarrant, 1982a and 1984a Warriss et al. 1984). Recently, the incidence of dark-cutting in a group of beef heifers was shown to be significantly correlated with the presence of oestrus at slaughter (Kenny and Tarrant, 1982b). Also, further investigation showed that oestrus can result in a sufficient depletion of muscle glycogen to cause a deterioration of meat quality. However, not all heifers were affected to the same extent and the role of the characteristic behaviour associated with oestrus in the depletion of muscle glycogen was not clear (Kenny and Tarrant 1984b).

The present experiment was designed to confirm the effect of oestrus on muscle glycogen depletion and to demonstrate its consequences in the development of dark-cutting beef, as well as to further explore whether dark-cutting at oestrus is due to endocrine change, physical activity or a combination of both.

Materials and Methods

Twenty-nine Hereford type heifers, penned indoors on slats and fed silage and barley were used. Mean liveweight at slaughter was 420 kg. The animals were housed in groups of 8, 8, 8 and 5. Each group was treated consecutively in time. Oestrus was synchronised in the four groups using a combination of PRID (progesterone releasing intravaginal device) implants and cloprostenol injections (Roche and Ireland, 1981).

Sampling: Muscle (M. longissimus dorsi) and venous blood samples were obtained from the resting animals before treatment, immediately before slaughter (blood) and 40 min after slaughter (muscle). Muscle biopsy samples were taken at the level of the third lumbar vertebra using the Bergstrom needle (Tarrant and McVeigh, 1979). Heart rate (by stethoscope) and rectal temperature were measured on the live animals, immediately before tissue sampling.

Oestrus behaviour: This was monitored on a video recorder. Recording commenced 48 h after removal of the PRIDS and continued until the animals were removed for slaughter (24 or 48 h later). The number of times each individual mounted, was mounted on or fell was noted from the recordings.

Analyses: Muscle glycogen was determined by extraction in perchloric acid (0.6M) and hydrolysis with amyloglucosidase and α-amylase. The glucose liberated was estimated by the modified glucose oxidase-peroxidase method of Bergmeyer and Bernt (1974). Plasma glucose concentration was also measured by the latter method. Creatine kinase (CK) activity was measured in fresh plasma using Boehringer CK-NAC Optimised Kit Number 126322. Using an Orion Model 221 pH meter equipped with an Orion electrode 91-03, the pH was recorded at 48h post mortem in M. longissimus at the third lumbar vertebra (LD), semitendinosus (ST), semimembranosus (SM), adductor (AD), gluteus medius (GM), psoas major (PM), biceps femoris (BF), triceps brachii caput laterale (TB), trapezius (TZ), infraspinatus (IS), supraspinatus (SS), longus colli (LC).

Statistical analysis was performed between the two groups using analysis of variance, Chi-square test or Mann-Whitney U test as indicated. Correlations were determined between behavioural and physiological (or carcass) variables. Simple and multiple regressions were performed where the correlations were significant.

Slaughter: The animals were slaughtered in early or late oestrus to give a range of stages of oestrus. They were weighed and transported in groups of 3, 3 and 2 for 20 miles and held for an average of 1 hr under observation before slaughter by captive bolt. Carcasses were scored for bruising on a scale from 1 to 5 (none, mild, moderate, severe, very severe).

Results

Examination of the reproductive tracts confirmed that all animals were close to or had recently ovulated except one pregnant animal which was dropped from the data. Analysis of behaviour (Table 1) showed that the animals could be divided into an inactive category (n = 10) that showed little physical activity prior to slaughter (less than 35 mounting interactions per animal) and an active category (n = 18) that showed substantial physical activity prior to slaughter (42 to 213 interactions per animal).

Changes in physiological parameters between resting and pre (or post) slaughter values were compared in these two groups (Table 1). There was no change in muscle glycogen content in the inactive group, while it fell to 44 percent of the resting value ($P < 0.001$) in the active group. The mean pH_u in the LD muscle in the inactive group was 5.48 vs. 5.92 in the active group. Seven out of eighteen carcasses in the active group had pH_u values above 6.0 versus none out of ten in the inactive group ($P < 0.05$). The overall level of carcass bruising was low, although there was significantly more bruising in the active than in the inactive group ($P < 0.05$). Plasma CK showed no change between resting and preslaughter values in the inactive group but increased significantly in the active group ($P < 0.001$). Plasma glucose showed similar increases in the active and inactive groups ($P < 0.001$).

Correlations between some oestrus behaviours and physiological or carcass characteristics are given in Table 2. Glycogen content in the LD muscle measured at 40 min post slaughter was inversely related to the number of times an animal mounted ($P < 0.001$) as well as to the number of times an animal was mounted on ($P < 0.001$). Simple and multiple regressions showed that the number of times an animal mounted accounted for 70.3 percent of the variance in muscle glycogen content (Figure 1), with the number of times an animal was mounted on or fell having little additional influence. When meat quality was assessed in terms of pH_u, the number of times an animal mounted was highly correlated with pH ($P < 0.001$) and regression showed that this accounted for 52.4 percent of the variance in pH_u. Carcass bruising was highly associated with mounting ($P < 0.001$) or being mounted on ($P < 0.001$), and regressions showed that being mounted on accounted for 53 percent of the variance of carcass bruising with little extra attributable to mounting or falls.

The only preslaughter value to show significant correlations was CK, which was highly associated with both mounting ($P < 0.01$) or being mounted on ($P < 0.01$). Regressions showed that 28.9 percent of the CK variance was attributable to being mounted on with little accounted for by the number of mounts or falls.

A profile of ultimate pH values for 12 muscles throughout the carcass is presented in Table 3. Oestrus dark cutters from the present experiment were compared with commercial dark-cutting heifers and normal commercial carcasses. The pH_u profile of the oestrus dark cutters was similar to that of the commercial dark cutters and both were different to the normal commercial carcasses.

TABLE 1: Differences in behaviour, physiology and carcass characteristics between heifers slaughtered in early (inactive group) or late (active group) oestrus

		Inactive Group (n = 10)	Active Group (n = 18)	Level of Significance[a]
Mounts		4.2	71.8	* * *[b]
Was mounted		6.1	72.1	* * *[b]
Falls		0.1	1.3	* * *[b]
Plasma CK (units/l)	Resting	38.8	42.8	N S
	Preslaughter	53.0	134.0	* *
	Change	14.0	91.0	* *
	Sig of change	N S	* * *	
Plasma glucose (mg/dl)	Resting	80.1	73.7	* *
	Preslaughter	97.5	94.4	N S
	Change	17.4	20.7	N S
	Sig of change	* * *	* * *	
Heart rate (bpm)	Resting	80.8	99.4	* *
	Preslaughter	102.4	100.9	N S
	Change	21.4	1.4	N S
	Sig of change	*	N S	
Temperature (°C)	Resting	38.75	38.87	N S
	Preslaughter	39.27	39.04	N S
	Change	0.51	0.12	*
	Sig of change	* *	N S	
Muscle glycogen (µmoles glucose /g wet tissue)	Resting	78.4	75.9	N S
	Postslaughter	80.3	33.7	* * *
	Change	1.9	-42.2	* * *
	Sig of change	N S	* * *	
pH_u (LD)		5.48	5.92	* * *
$pH_u > 6.0$ (LD)		0	7	*[c]
Bruising score		1.03	1.35	* * *[b]

[a] The level of significance was determined by analysis of variance except where otherwise indicated. *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$, NS not statistically significant

[b] Mann-Whitney U test

[c] Chi-square test

TABLE 2: Correlations between some oestrus behaviours and physiological or carcass characteristics in beef heifers slaughtered at oestrus

	Mounts	Was mounted on	Falls
C K[1]	0.51[3]	0.54	0.11
Glucose[1]	0.05	0.15	-0.03
Heart Rate[1]	0.25	0.13	-0.01
Temperature[1]	-0.34	-0.27	-0.24
Glycogen[2]	-0.85	-0.71	-0.31
pH_u	0.74	0.34	0.17
Bruising	0.61	0.74	0.29

[1] Measured preslaughter

[2] Measured 40 min post slaughter in the LD muscle

[3] Correlation coefficients are significant at the following levels of probability. $P < 0.05$ r = 0.38; $P < 0.01$ r = 0.49; $P < 0.001$ r = 0.60, for 25 degrees of freedom (n = 26)

TABLE 3: A comparison of dark-cutting carcasses from oestrus heifers with commercial dark-cutting heifers and commercial normal carcasses, for ultimate pH values in twelve muscles

	(1) Oestrus dark cutters[1]				(2) Commercial dark-cutting heifers[2]				(3) Commercial[3] normal			
	Mean	SE	n	t-values[4] 1 v 2	Mean	SE	n	t-values[4] 2 v 3	Mean	SE	n	t-values[4] 1 v 3
LD	6.26	.090	7	0.11	6.25	.028	31	12.84***	5.59	.040	34	7.41***
ST	5.85	.115	7	-1.40	6.02	.037	32	6.90***	5.55	.054	34	2.48*
SM	5.73	.100	7	-1.34	5.88	.039	32	5.41***	5.54	.047	34	1.71
AD	5.78	.092	7	-0.83	5.87	.039	32	5.26***	5.55	.045	34	2.13*
GM	5.79	.170	7	0.19	5.77	.027	30	3.69***	5.55	.041	34	2.31*
PM	5.62	.029	7	-0.55	5.66	.032	31	2.45*	5.56	.027	34	0.84
BF	5.62	.076	7	0.00	5.62	.026	32	1.93	5.54	.030	34	1.09
TB	5.71	.052	7	-1.06	5.81	.046	32	2.82**	5.66	.029	34	0.53
TZ	5.81	.099	7	-1.57	5.98	.053	25	3.39**	5.76	.037	31	0.47
IS	5.89	.100	7	1.03	5.82	.021	30	2.59*	5.72	.026	34	2.53*
SS	5.86	.088	7	-1.48	5.99	.037	30	3.22**	5.83	.031	34	0.35
LC	5.88	.051	7	-1.54	6.01	.036	31	3.14**	5.86	.032	34	0.24

1 Carcasses from the present experiment with $pH_u \geq 6$ in the LD muscle
2 Values for heifer carcasses of $pH_u \geq 6$ in the LD, abstracted from the data of Tarrant and Sherington (1980)
3 From Tarrant and Sherington (1980), ($pH_u \leq 5.75$ in the LD)
4 The t-values have an approximate student's t distribution

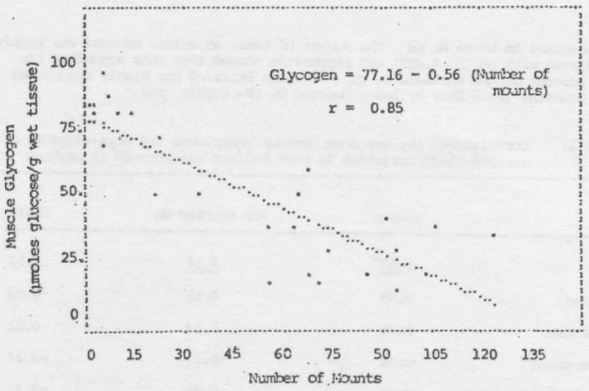

Figure 1. Regression of muscle glycogen on number of times an animal mounted during oestrus. Glycogen concentration was measured in the LD muscle at 40 min after slaughter

Conclusions

1. Although all the animals were in oestrus the degree to which meat quality was affected depended on the level of physical activity exhibited.
2. Low muscle glycogen/high pH_u was attributed to the number of times an animal mounted.
3. Carcass bruising was attributed to the number of times an animal was mounted on.
4. Similarities in pH_u profiles of carcasses suggest that oestrus may have been a cause of dark-cutting in commercial heifer carcasses.
5. Single penning of oestrus heifers to eliminate mounting activity should substantially reduce the incidence of dark-cutting in these animals.

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References

BERGMEYER, H.U. & BERNT, E., 1974. In: Methods of Enzymatic Analysis, 2nd English edn., 1212, ed. H.U. Bergmeyer. Academic Press (New York and London).

HOOD, D.E. & TARRANT, P.V. (eds) 1981. 'The problem of dark-cutting in beef', Martinus Nijhoff, The Hague.

KENNY, F.J. & TARRANT, P.V. 1982a. In: 'Transport of animals intended for breeding, production and slaughter', (ed R Moss) 87-102, Martinus Nijhoff, The Hague.

KENNY, F.J. & TARRANT, P.V., 1982b. An Foras Taluntais, Food Science and Technology Research Report, p 8 (Dublin).

KENNY, F.J. & TARRANT, P.V., 1984a. (Influence of preslaughter behaviour on meat quality). Proc. International Congress on Applied Ethology in Farm Animals, Kiel, 1-4 August, 1984.

KENNY, F.J. & TARRANT, P.V., 1984b. (The effect of oestrus behaviour on muscle glycogen concentration in beef heifers). Proc. Eur. Assoc. Anim. Prod. 35th Ann. Mtg. 6 - 9 August 1984, The Hague.

ROCHE, J.F. & IRELAND, J.J. 1981. J. Anim. Sci., 52, 580-586.

TARRANT, P.V. & McVEIGH, J.M. 1979. Res. Vet. Sci., 27, 325-328.

TARRANT, P.V. & SHERINGTON, J. 1980. Meat Science 4, 287-297.

WARRISS, P.D., KESTIN, S.C., BROWN, S.N. & WILKINS, L.J. 1984. Meat Science, 10, 53-68.