INTENSIVE FEEDING OF NORWEGIAN YOUNG BULLS AND ITS EFFECTS ON MUSCLE CARBOHYDRATE CONCENTRATION, ULTIMATE-pH AND BEEF QUALITY

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Background

Large effort and money has been invested in the Norwegian meat industry to minimize the stress that cattle are exposed to during loading, unloading, transportation and overnight lairage. Even though, a recent survey including 1850 young bulls slaughtered at three abattoirs, indicated a somewhat higher ultimate-pH (pH_u) compared to data from other countries. Due to the agricultural structure in Norway, with a domination of farmers with a low number animals, very little additional changes can be made by the industry to reduce transportation time to the abattoir. However, it is desirable to lower the incident of animals with pH_u over 5,7 to improve meat quality and shelf life. Immonen *et al* (2000) showed that finishing feeding of young bulls *ad libitum* with high-energy diets resulted in higher muscle glycogen levels and had a overall protective effect against glycogen losses during transportation corresponding to 0.65 pH units.

Objective

The aim of the present project was to lower the overall pH_u and the percentage of moderate DFD animals, by finish feeding young bulls with high-energy concentrate four weeks before slaughter. The effects finish feeding had on glycogen deposits, pH coarse and pH_u, meat quality and muscle shortening were investigated. Beef quality measurements were related to pH_u.

Material & Method

The experiment involved 185 young bulls, divided evenly into two sessions with two diet groups at both times. They were finish fed one month prior to slaughter, with the extensive group given a concentrate diet of 2 kg a day in addition to free access to roughage in both sessions. The intensive group also had free access to conventional roughage, and was given 4 kg of high-energy concentrate a day in session 1 and close to *ad libitum,* 8 kg a day (4 kg special concentrate and 4 kg conventional concentrate) in session 2. The animals were collected at the farmers, transported 5 hours with a total of 6 stops and kept overnight at lairage with access to both water and roughage. When possible the animals were housed in single pens. Animals were slaughtered (not electrically stimulated.) and chilled according to the normal procedures at three abattoirs. The pH was measured directly in the LD and SM muscles of all carcasses using a combination puncture electrode. Further analyses were only performed on carcasses from session 1, and represent both diet groups. A small meat sample was excised from the right side of LD of 52 carcasses, 20-40 minutes *post mortem* for glycogen and lactate assessment. The samples were frozen in liquid nitrogen and stored at -20°C until use. Total glucose was determined with the use of amyloglucosidase, and lactate was determined by the use of kit from Boehringer Mannheim. Warner Bratzler shear force analysis was performed on 24 selected carcasses. LD samples were aged 4, 11 and 21 days and SM samples were aged 4 and 11 days. A small piece from LD was excised 48 hours *post mortem* from 48 carcasses and prepared for sarcomere length measurements using light microscope. LD and SM of 24 carcasses were selected for sensory analysis, LD was aged 7 and 14 days and SM was aged 8 days. 1.5 cm thick fresh samples were fried in a buttered pan until a core temperature of 70°C had been attained. 12 highly trained panelists from performed a descriptive including 17 sensory qualities. All results were analyzed using the GLM procedure of SYSTAT®9.

Results & Discussion

Figure 1 shows the pH_u distribution for both the Norwegian background material and from the present study. The mean pH_u of LD of the Norwegian background material is 5,63 ± 0,23 in comparison to a mean pH_u of 5,72 ± 0,31 in this study. The mean pH_u of SM is 5,49 ± 0,21. A large proportion of animals with serious DFD (pH_u>6.0) can explain the high value of LD. There was no significant difference in pH between the intensive and extensive diets at any given time, there is however differences early *post mortem* between the two sessions (Table 1). Total glucose concentration, shear force, sarcomere length (SML), tenderness and juiciness was not affected by diet (Table 2). Total glucose concentration had however a significant effect on pH_u, but only the highest pH_u range differs significantly from the lower pH_u ranges (Table 3). Purchas (1990) demonstrated an increase in beef tenderness of pH_u values above 6,1, but no such significant effect was found here, although such a tendency may be observed. This is further supported by neither a significant effect of pH_u on sarcomere length, nor a significant decrease of WB shear force of 4 and 11 days aging of LD and 4 and 11 days aging of SM. The moderate DFD group of 21 days aging of LD is however significantly more tender then the lower and acceptable pH_u groups. DFD meat is often associated with high water holding capacity, WHC, (Petchick *et al*, 1995), no significant improved juiciness was however found in this study. Increased WHC is associated with a darker color, and in addition, an increase in pH_u affects the oxygenation of myoglobin which results in darker meat color (Ledward *et al*, 1992). This study demonstrates an increase of both color tone and stale taste of SM and LD with increasing pH_u at all aging times. Color tone differs only significantly between the acceptable pH_u ranges and the serious DFD group, whereas the moderate DFD group does not differ significantly between either groups. The serious DFD group differs significantly in stale taste from all the other pH_u groups, but these do not differ significantly from each other, Table 3 and 4.

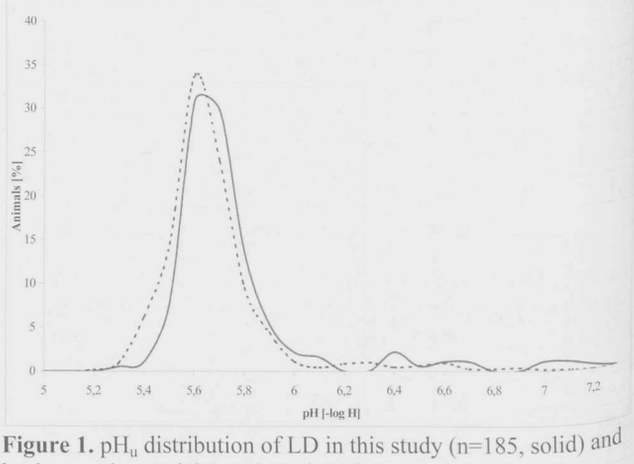

Figure 1. pH_u distribution of LD in this study (n=185, solid) and background material (n=1850, dotted

Conclusions

No significant effect was found between the two diet groups, and ultimate pH of LD was not lowered with respect to the previous Norwegian survey. The group with serious DFD differed significantly in total glucose concentration, stale taste and color tone from the lower pH_u ranges. No significant effect of pH_u ranges was found in respect to sarcomere length WB shear force, sensorial tenderness and juiciness.

Table 1. Mean and SD of LD pH measurements (< 6,1 at 24 h *pm*) with respect to session and diet. Different superscription within column indicates significant difference (p<0,05). *** 99,9% significance.

Comb.	pH-measurement [h] *post mortem*				
	n	1	4	10	24
Sess.1 Int.	48	6,76±0,17[a]	6,24±0,29[a]	6,01±0,29	5,64±0,09
Sess.1 Ext	43	6,76±0,19[a]	6,22±0,28[a]	6,00±0,27	5,64±0,10
Sess.2 Int.	41	6.89±0,17[b]	6.54±0,21[b]	6.04±0,26	5.62±0,14
Sess.2 Ext	35	6.88±0,13[b]	6.46±0,27[b]	5,99±0,23	5.64±0,11
		***	***	ns	ns

Table 2. Mean and SD of LD measurements; Sensorial qualities [1-9] with increasing intensity from 1-9, total carbohydrate concentration [mmol glucose/kg fresh meat], lactate concentration [mmol LA/kg fresh meat], sarcomere length [µm] and WB shear force [N] in respect to diet. n is evenly divided between the two groups.

Diet	Tenderness LD 7d, n=24	Tenderness LD 14d, n=24	Tenderness SM 8d, n=24	Juiciness LD 7d, n=24	Juiciness LD 14d, n=24	Juiciness SM 8d, n=24	Total glucose LD, n=52
Int.	5,0±1,6	6,0±1,2	3,6±0,8	6,1±0,3	6,1±0,4	5,7±0,3	51,7±24,7
Ext.	4,3±1,6	5,5±1,6	3,7±0,7	5,8±0,5	6,1±0,4	5,8±0,4	46,9±21,2
	ns	ns	ns	ns	ns	ns	ns
	WB LD 4d n=24	WB LD 11d n=24	WB LD 21d n=24	WB SM 4d n=24	WB SM 11d n=24	SML LD n=48	Lactate LD n=52
Int	123,6±14,8	114,3±19,6	112,3±22,1	104,4±5,3	99,7±10,6	1,7±0,2	21,5±8,0
Ext.	120,8±23,2	107,5±20,9	100,2±18,2	108,8±17,4	103,3±21,2	1,7±0,2	24,4±8,4
	ns	ns	ns	ns	ns	ns	ns

Tabel 3: Mean and SD of LD measurements; Sensorial qualities [1-9] with increasing intensity from 1-9, total carbohydrate concentration [mmol glucose/kg fresh meat], sarcomere length [µm] and WB shear force [N] in respect to different pH_u ranges. Different superscription within column indicates significant difference (p<0,05). * 95% significance, ** 99% significance, *** 99,9% significance

pH range	Sens. n	Tender 7d	Juicy 7d	Stale 7d	Color tone 7d	Tender 14 d	Juicy 14 d	Stale 14d	Color tone 14d
-5,6	7	4,8±2,1	6,1±0,4	1,9±0,5[a]	5,3±0,3[a]	5,8±1,8	6,4±0,3	1,5±0,5[a]	5,1±0,1[a]
5,61-5,8	6	4,2±1,2	5,8±0,6	1,9±0,4[a]	5,2±0,5[a]	5,8±1,0	6,1±0,3	1,6±0,4[a]	4,9±0,5[a]
5,81-6,1	5	3,7±1,4	5,9±0,2	1,6±0,2[a]	5,4±0,5[ab]	4,8±1,7	5,9±0,3	1,5±0,2[a]	5,2±0,7[ab]
6,11-	6	5,9±0,7	5,9±0,2	3,4±1,0[b]	6,2±0,5[b]	6,5±0,5	5,9±0,4	4,5±1,0[b]	5,9±0,7[b]
		ns	ns	***	**	ns	ns	***	*
pH range	SML n	SML	WB n	WB 4d	WB 11d	WB 21d	Gluc. n	Total glucose	pH tot.gluc
-5,6	15	1,7±0,2	8	126,6±13,9	120,2±16,6	120,4±16,6[a]	15	60,60 ± 11,37[a]	5,55 ± 0,06
5,61-5,8	20	1,7±0,3	14	123,3±20,6	109,2±20,1	101,3±19,5[ab]	21	57,36 ± 13,76[a]	5,68 ± 0,05
5,81-6,1	7	1,7±0,2	2	97,2±10,5	86,1±14,0	83,8±7,5[b]	7	50,66 ± 27,24[a]	5,94 ± 0,09
6,11-	6	1,7±0,3	-	-	-	-	9	11,08 ± 7,29[b]	6,74 ± 0,28
		ns		ns	ns	*		***	

Table 4: Mean and SD of SM measurements; Sensorial qualities [1-9] with increasing intensity from 1-9 and WB shear force [N] in respect to different pH_u ranges. Different superscription within column indicates significant difference (p<0,05). *** 99,9% significance

pH range	Sensory n	Tender 8d	Juicy 8d	Stale 8d	Colortone 8d	WB n	WB 4d	WB 11d
-5,4	5	3,7±0,6	5,8±0,3	1,9±0,4[a]	5,4±0,6[a]	7	103,9±7,0	100,4±13,5
5,41-5,6	14	3,4±0,7	5,7±0,4	2,1±0,5[a]	5,2±0,4[a]	16	106,3±13,8	99,9±16,5
5,61-5,8	1	4,7	6,1	2,5[a]	5,4[ab]	1	129,9	133,7
5,81-	4	4,3±0,7	5,7±0,1	4,6±0,2[b]	6,4±0,2[b]	-	-	-
Sign.		ns	ns	***	***		ns	ns

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