TECH REPORT

EVALUATING THE EFFECTS OF HANDLING INTENSITY AND OPTAFLEXX® ON THE PHYSIOLOGICAL RESPONSE AND MOBILITY OF BEEF CATTLE DURING TRANSPORT FOR HARVEST[1,2]

TWO CATTLE WELFARE STUDIES UNCOVER NEW LEARNINGS

Two field trials were conducted to evaluate the effects of two factors — handling intensity and feeding Optaflexx® — on the physiological responses and mobility during transport for slaughter in feedlot cattle. The findings of these studies highlight the importance of low-stress handling in cattle at the time of shipment for slaughter and demonstrate that Optaflexx does not impact mobility at the feedyard.

STUDY 1

EFFECT OF HANDLING INTENSITY AT THE TIME OF TRANSPORT FOR SLAUGHTER ON PHYSIOLOGICAL RESPONSE AND CARCASS CHARACTERISTICS IN BEEF CATTLE FED OPTAFLEXX[1]

The first study highlights the importance of low-stress handling at the time of transport for slaughter. Metabolic acidosis, a predisposing factor for fatigued cattle, was observed in cattle trotted without a lead rider.[1]

MATERIALS AND METHODS[1]

- The study was conducted during August of 2014 at a commercial feedlot in Kansas[1]
- Complete randomized block design:
  – 80 steers (BW = 668 ± 36 kg) representing 10 lots that had been fed Optaflexx were selected.
- Within a lot (n = 10 replicates), cattle were stratified by weight and randomly assigned in groups of 4 penmates to 1 of 2 handling intensity (HI) treatments: 1) low-stress handling (LSH) or 2) high-stress handling (HSH):
  - LSH: cattle were kept at a walking pace with the use of a lead rider to keep cattle at a reduced speed and a handler behind the cattle to prevent cattle from reversing direction. Electric prods were not applied at any point during the study.
  - HSH: cattle were kept at a minimum of a trot without the use of a lead rider. Two applications (approximately 1 second per impulse) of an electric prod were applied while cattle were in the alley before post-handling sampling and again during loading onto trailers for transport to the abattoir.
- HI treatments were applied over a 1,600-meter dirt alley course over 2 days.
- Cattle were harvested on the same day as handling and day served as a blocking factor.
- Cattle within a replicate were comingled after post-handling measurements and loaded into the same trailer compartment for transport.

MEASUREMENTS[1]

- Venous blood samples were collected one hour before handling (baseline) and immediately after handling (POSTHAND) at the feedyard. A third mixed arterial and venous blood sample was collected during exsanguination at harvest.
- Mobility was assessed at three different times using the 4-point scoring system[3] developed by the North American Meat Institute (NAMI) — before both blood collections at the feedyard (baseline and POSTHAND) and again immediately before slaughter.
- Additional behavioral metrics were evaluated and reported in the full peer-reviewed publication.[1]

STATISTICAL ANALYSIS[1]

- Cattle receiving a mobility score greater than 1 were considered abnormal, and chi-squared tests were performed using the FREQ procedure in SAS.
- Blood variables were analyzed using the GLIMMIX procedure with HI groups of 4 considered the experimental unit. The statistical model included the fixed effects of HI and the random effects of replicate and block.
- Comparisons between fatigued and non-fatigued HSH cattle were analyzed, with the individual animal serving as the experimental unit. The statistical model was similar to the model used for HI on continuous variables, except fatigue status was added as a fixed effect. Due to all fatigued cattle coming from the HSH treatment, HI was removed from the model and data for LSH cattle were omitted from the analyses.
- Statistically significant differences between estimates were determined by $P \le 0.05$ and tendencies were declared when $0.05 < P \le 0.10$.

Study note: Data describing blood variables at the time of slaughter were not available from cattle slaughtered in the first block due to the failure to maintain sample integrity and sequence in the abattoir[2].

STUDY RESULTS*

TABLE 1 EFFECTS OF HANDLING INTENSITY (HI) ON THE DISTRIBUTION OF MOBILITY SCORES IN BEEF CATTLE AT BASELINE, POSTHAND AND IMMEDIATELY BEFORE SLAUGHTER

	Baseline*						POSTHAND* Mobility score						Slaughter*					
HI treatment**	1	2	3	4	% > 1	*P*-value	1	2	3	4	% > 1	*P*-value	1	2	3	4	% > 1	*P*-value
LSH	37	3	0	0	7.5	0.24	34	2	0	0	5.5	1.00	30	9	1	0	25.0	0.59
HSH	40	0	0	0	0.0	0.24	29	3	0	0	9.4	1.00	32	5	3	0	20.0	0.59
Total	77	3	0	0	3.8	(n = 80)	63	5	0	0	7.4	(n = 68)***	62	14	4	0	22.5	(n = 80)

*At the feedyard, samples were collected one hour before handling (baseline) and immediately after handling (POSTHAND). At the abattoir, samples were collected during exsanguination at harvest (slaughter).
**Handling Intensity (HI) treatments included low-stress handling (LSH) or high-stress handling (HSH).
***Missing data due to recording errors

NAMI Mobility Scoring System[3]

1	Normal, walks easily, no apparent lameness, no change in gait
2	Exhibits minor stiffness, shortness of stride, slight limp, keeps up with normal cattle
3	Exhibits obvious stiffness, difficulty taking steps, obvious limp, obvious discomfort, lags behind normal cattle
4	Extremely reluctant to move even when encouraged by handler; statue-like

TABLE 2 LEAST SQUARES MEANS FOR THE EFFECTS OF HANDLING INTENSITY (HI) ON BASELINE BLOOD VARIABLES AND THE CHANGES FROM BASELINE TO POSTHAND AND SLAUGHTER

	Baseline				POSTHAND — Baseline				Slaughter — Baseline			
	HI treatment				HI treatment				HI treatment			
Variable	LSH	HSH	SEM[a]	*P*-value	LSH	HSH	SEM[a]	*P*-value	LSH	HSH	SEM[a]	*P*-value
BW, lbs	1477	1470	4.7	0.51								
Blood Variables												
Lactate, mmol/L	5.8	5.2	0.74	0.49	-1.4	9.0	1.37	<0.0001	5.5	5.4	1.46	0.95
HCO_3, mmol/L[b]	25.4	25.4	1.28	0.97	0.5	-8.3	1.90	<0.0001	-0.3	0.1	1.24	0.82
pH	7.38	7.38	0.009	0.94	0.06	-0.09	0.018	<0.0001	—	—	—	—
pCO_2, mmHg[b]	47.1	46.9	2.09	0.86	-6.2	-12.4	2.97	<0.01	—	—	—	—
Epinephrine, pg/mL	1,176	1,045	366.8	0.61	152	1,131	535.3	0.02	3,431	4,371	882.1	0.48
Norepinephrine, pg/mL	1,239	1,178	387.4	0.82	-445	1,013	1,174.3	0.02	5,015	5,879	1,138.0	0.61
Cortisol, ng/mL	39.1	37.5	4.63	0.73	1.6	11.0	5.59	<0.01	27.5	18.6	5.37	0.20
Creatine kinase, U/L	266	250	15.1	0.58	1,537	973	256.0	0.13	7,309	8,253	4,738.4	0.86
Glucose, mg/dL	101	95	4.3	0.29	0.9	166	11.6	<0.0001	40	40	5.1	0.99

[a]SEM = largest SE in the analysis; n = 10 for LSH and HSH groups at POSTHAND; n = 4 for LSH and HSH groups at slaughter.
[b]HCO_3 = bicarbonate; pCO_2 = partial pressure carbon dioxide.

TABLE 3 LEAST SQUARES MEANS FOR THE EFFECTS OF FATIGUE STATUS (FATIGUED VS. NON-FATIGUED) ON THE CHANGE IN BLOOD VARIABLES FROM BASELINE TO POSTHAND

	STATUS			
Variable	Fatigued	Non-fatigued	SEM[a]	*P*-value
Blood Variables				
Lactate, mmol/L	18.8	8.1	2.9	< 0.001
HCO_3, mmol/L[b]	- 15.2	- 7.5	3.2	< 0.01
pH	- 0.25	- 0.07	0.06	< 0.01
pCO_2, mmHg[b]	- 16.3	- 12.0	4.6	0.27
Epinephrine, pg/mL	3,000	1,011	989	0.06
Norepinephrine, pg/mL	3,390	871	1,435	0.04
Cortisol, ng/mL	22.1	9.3	10.0	0.09
Creatine kinase, U/L	399	568	286	0.61
Glucose, mg/dL	251	156	41.8	0.03

[a]SEM = largest SE in the analysis; n = 4 for fatigued and n = 36 for non-fatigued groups.
[b]HCO_3 = bicarbonate; pCO_2 = partial pressure carbon dioxide.

STUDY 1 KEY FINDINGS

The results emphasize the importance of low-stress handling of Optaflexx-fed beef steers at the time of transport for slaughter. When evaluated in steers that had been fed 400 mg/hd/d Optaflexx for 35-36 days, high- versus low-stress handling on the day of transport to slaughter resulted in:

- The development of metabolic acidosis, an acknowledged precursor to fatigued cattle syndrome[4]
- Four fatigued animals, with a degree of metabolic acidosis that was more severe compared to their non-fatigued cohorts
- Greater concentrations of stress hormones before leaving the feedyard, such as cortisol, epinephrine and norepinephrine
- Creatine Kinase (CK), an enzyme released during the breakdown of muscle, was greater at the time of slaughter than at the feedyard

STUDY 2

EFFECTS OF OPTAFLEXX ON GROWTH PERFORMANCE, CARCASS CHARACTERISTICS, AND PHYSIOLOGICAL RESPONSE TO DIFFERENT HANDLING TECHNIQUES[2]

The second study evaluated Optaflexx related to handling intensity. In addition to aggressive handling inducing acid-base changes that were consistent with the first trial, this study demonstrated that feeding Optaflexx does not affect mobility at the feedyard or following lairage at the abattoir. Furthermore, feeding Optaflexx increased carcass weight without altering an array of baseline blood variables.[2]

MATERIALS AND METHODS[2]

- The study was conducted over a 30-day period in the summer of 2015 at a Nebraska feedlot.
- A total of 128 crossbred Bos taurus steers and heifers (BW = 1210.34 ± 132.28 lbs) were evaluated in a two-phase study:
  - **Phase 1 (feeding phase):** The effects of feeding Optaflexx for 28 days on growth performance and carcass characteristics
  - **Phase 2 (handling phase):** The effects of Optaflexx and HI on the physiological response and mobility during transport for slaughter
- Feeding phase (28 days): Randomized block design:
  - Cattle were segregated by sex (n = 64 steers; n = 64 heifers), stratified by BW, and randomly allocated to 16 pens to form 8 single-gender replicates. Within a replicate, the pens were randomly assigned to receive 1 of 2 diets that provided either 400 mg/hd/d of Optaflexx or did not contain a beta-agonist. The 2 pens representing a replicate were adjacent
  - The treatment diets were fed for 28 days, and the start date was staggered over 2 days to comply with the handling phase. Thus, start date served as a blocking factor, and each block consisted of 4 single-gender replicates
- Handling phase: Split-plot design with a 2 × 2 factorial arrangement of treatments:
  - Factor 1: Diet (control vs. Optaflexx)
  - Factor 2: Handling intensity (LSH vs. HSH)
  - Diet was evaluated within HI treatments for each single-gender replicate by combining adjacent pens to reate 2 single-sexed handling groups, each composed of 4 controls and 4 Optaflexx cattle
  - HI treatments were similar to those described for study #1, and were applied over a 1,500-meter dirt alley course on the day of transport to slaughter
    - Similar to study #1, mobility scores and biochemical markers of stress were the primary variables of interest and were measured at baseline, POSTHAND and immediately before/during slaughter

Study note: An additional blood sample was pulled on a subset of cattle following transport and unloading at the abattoir. Behavioral observations and mobility scores were also recorded at this time, and these measurements are reported in the full peer-reviewed publication.[2]

STATISTICAL ANALYSIS[2]

- Feeding phase:
  - Experimental unit = pen (8 pens per diet)
  - Linear mixed effects model using the GLIMMIX procedure in SAS with diet included as a fixed effect and block and replicate included as random effects
  - Growth performance was based on unshrunk initial and final body weight, whereas dressing percentage was calculated by adjusting the final BW for a 4% shrink (BW × 0.96) and dividing the HCW by the adjusted BW
- Handling phase:
  - Handling groups of 8 cattle were the experimental unit for the whole plot effect of HI (n = 8 groups per HI) and the sub-groups of 4 cattle representing each diet were considered the experimental unit for the sub-plot (n = 16 groups per diet)
  - Blood variables were analyzed using the GLIMMIX procedure in SAS. The statistical model included the fixed effects of diet, HI and the diet x HI interaction and the random effects of replicate and the replicate x HI interaction
  - Mobility scores > 1 were considered an abnormal event, and the data were analyzed as a binary variable using the logit link function within the GENMOD procedure of SAS
  - Statistically significant differences were determined by $P \leq 0.05$ and tendencies were declared when $0.05 < P \leq 0.10$

STUDY RESULTS*

TABLE 4

LEAST SQUARES MEANS FOR THE EFFECTS OF OPTAFLEXX (OPT) ON GROWTH PERFORMANCE AND CARCASS CHARACTERISTICS

	DIET			
Variable	CON	OPT	SEM[a]	*P*-value
Growth performance				
Initial body weight, lbs	1,208	1,208	41.8	0.93
Final Body Weight, lbs	1,296	1,314	53.5	0.11
Dry-matter intake, lbs	18.6	19.0	0.493	0.11
Average daily gain, lbs	2.91	3.53	0.193	0.06
Gain: Feed, lb:lb	0.156	0.186	0.0130	0.06
Carcass characteristics				
Hot carcass weight (HCW), lbs	785	800	31.3	0.04
Dressing percentage[b]	63.1	63.4	0.26	0.49
Ribeye area, in^2	13.6	14.2	0.36	0.04
12^{th} rib fat thickness, in	0.18	0.17	0.029	0.34
Marbling score	451	455	12.7	0.78

[a]SEM = largest SE in the analysis.
[b]Final BW was adjusted for 4% shrinkage before calculation and statistical analysis of dressing percentage.

TABLE 5

EFFECTS OF OPTAFLEXX (OPT) AND HANDLING INTENSITY (HI) ON PERCENTAGE OF CATTLE RECEIVING MOBILITY SCORES GREATER THAN 1 AT EACH TIME POINT*

	Diet[2]			HI[2]		
Time point	CON	OPT	*P*-value[3]	LSH	HSH	*P*-value[3]
Baseline	1.6%	0.0%	1.00	1.6%	0.0%	1.00
POSTHAND	1.5%	4.7%	1.00	6.3%	0.0%	1.00
Slaughter	23.4%	17.1%	0.43	26.5%	14.0%	0.11

*Values reported are arithmetic means, while the *P*-values signify differences in least squares means for the probability of cattle receiving a mobility score greater than 1. The diet × HI interaction could not be tested due to 0 observed events within at least 1 treatment interaction subclass. The interaction for lairage observations was insignificant and removed from the model.

TABLE 6

LEAST SQUARES MEANS FOR THE EFFECTS OF OPTAFLEXX (OPT) AND HANDLING INTENSITY (HI) ON BASELINE BLOOD VARIABLES OF BEEF CATTLE

	Diet				HI			
Variable	CON	OPT	SEM[a]	*P*-value	LSH	HSH	SEM[a]	*P*-value
Weight, lbs	231.5	234.65	3.1	0.09	232.28	234.25	3.0	0.21
Blood variables								
Lactate, mmol/L	5.4	4.1	0.39	0.001	4.8	4.7	0.39	0.89
pH	7.42	7.43	0.010	0.19	7.43	7.42	0.010	0.51
HCO_3,[b] mmol/L	23.7	24.6	0.28	< 0.01	24.2	24.2	0.28	0.92
pCO_2,[b] mmHg	43.2	44.2	0.68	0.10	43.6	43.8	0.68	0.71
Epinephrine, pg/mL	428	273	59.3	0.02	335	366	64.6	0.71
Norepinephrine, pg/mL	641	614	75.7	0.59	627	628	78.9	0.99
Cortisol, ng/mL	30.7	29.7	1.89	0.69	31.9	28.5	1.89	0.19
Creatine kinase, U/L	255	232	80.8	0.67	220	268	85.3	0.39
Glucose, mg/dL	101	93	3.8	0.08	98	97	4.0	0.73
Potassium, mmol/L	5.02	5.24	0.068	0.01	5.14	5.12	0.068	0.84

[a]SEM = largest SE in the analysis.
[b]HCO_3 = bicarbonate; pCO_2 = partial pressure carbon dioxide.

TABLE 7

LEAST SQUARES MEANS FOR THE EFFECTS OF OPTAFLEXX (OPT) AND HANDLING INTENSITY (HI) ON THE CHANGE IN PHYSIOLOGICAL MEASUREMENTS AND BLOOD VARIABLES FROM BASELINE TO POSTHAND

	Diet				HI			
Variable	CON	OPT	SEM[a]	*P*-value	LSH	HSH	SEM[a]	*P*-value
Blood variables								
Lactate, mmol/L	2.1	3.0	0.75	0.26	-1.7	6.8	0.77	< 0.0001
pH	0.01	-0.02	0.017	0.04	0.06	-0.07	0.019	< 0.001
HCO_3,[b] mmol/L	-2.1	-2.9	0.76	0.19	1.4	-6.4	0.81	< 0.0001
pCO_2,[b] mmHg	-6.0	-6.1	0.81	0.83	-4.4	-7.7	0.85	< 0.01
Norepinephrine, pg/mL	522	716	108.4	0.05	346	892	109.6	< 0.001
Cortisol, ng/mL	10.3	11.6	1.50	0.54	3.7	18.2	1.50	< 0.001
Creatine kinase, U/L	267	307	133.2	0.68	258	317	112.3	0.62
Glucose, mg/dL	47	55	6.7	0.42	-2	104	6.7	< 0.0001

[a]SEM = largest SE in the analysis.
[b]HCO_3 = bicarbonate; pCO_2 = partial pressure carbon dioxide.

TABLE 8

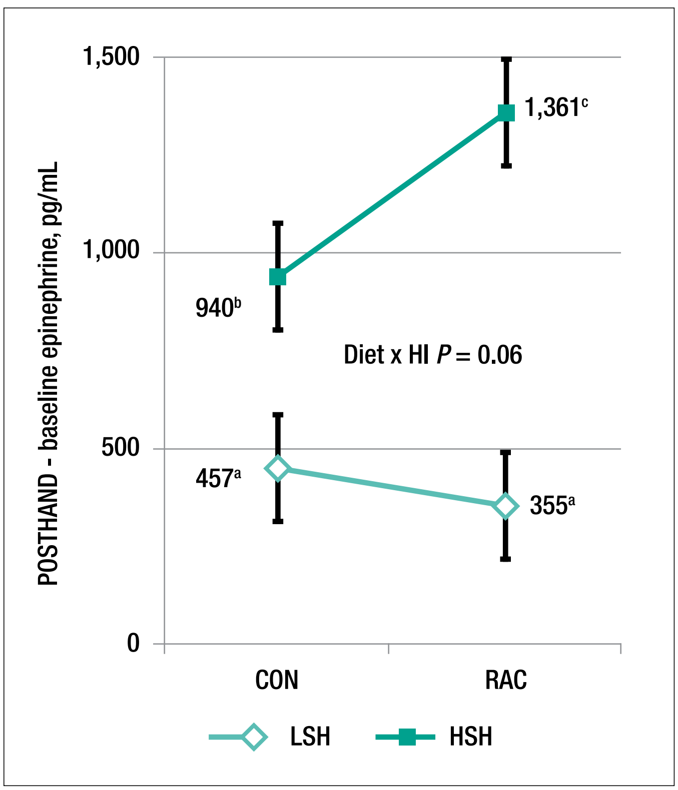
LEAST SQUARES MEANS FOR THE EFFECTS OF OPTAFLEXX (OPT) AND HANDLING INTENSITY (HI) ON THE OVERALL CHANGE IN BLOOD VARIABLES OF BEEF CATTLE FROM BASELINE TO SLAUGHTER BLOOD COLLECTIONS*

	Diet				HI			
Variable	CON	OPT	SEM[a]	*P*-value	LSH	HSH	SEM[a]	*P*-value
Blood variables								
Lactate, mmol/L	6.3	7.0	0.52	0.12	6.3	6.9	0.52	0.16
HCO_3, mmol/L	2.3	2.8	0.31	0.19	2.7	2.3	0.32	0.29
Epinephrine, pg/mL	7,569	7,571	321.4	0.99	7,502	7,638	321.4	0.63
Norepinephrine, pg/mL	8,036	8,004	446.0	0.96	7,703	8,337	446.0	0.35
Cortisol, ng/mL	20.0	21.9	2.21	0.56	18.6	23.3	2.21	0.17
Creatine kinase, U/L	2,157	4,077	1,278.1	< 0.001	1,838	4,787	1,208.1	< 0.01
Glucose, mg/dL	74	62	9.0	0.36	75	61	9.0	0.33

*pH and partial pressure carbon dioxide (pCO2) could not be measured since blood was exposed to atmospheric gases during collection.
[a]SEM = largest SE in the analysis.

CHART 1

DIET × HANDLING INTENSITY (HI) INTERACTION FOR THE CHANGE IN EPINEPHRINE CONCENTRATIONS FROM BASELINE TO POST-HANDLING (POSTHAND) PROCEDURES



STUDY 2 KEY FINDINGS

This study confirms the growth performance advantages from feeding Optaflexx and the negative implications of aggressive handling.

- Optaflexx improved growth performance without altering ` baseline blood variables
  - Optaflexx improved ADG by 21%, feed efficiency by 20% and increased HCW by 15.43 lbs
- Regardless of diet, aggressive handling resulted in the development of metabolic acidosis and increased stress hormones
  - Diet interacted with handling intensity for post-handling epinephrine (Chart 1); Optaflexx increased epinephrine in HSH cattle but had no effect on epinephrine concentrations in cattle that were handled in a low-stress manner
  - These findings emphasize the importance of low-stress handling of all cattle, including cattle fed growth-promoting technologies
- Mobility was not affected by Optaflexx at the feedlot or following a 6-hour lairage
  - The risk of fed cattle having impaired mobility appeared to be greatest following transport and lairage at the abattoir
- Feeding Optaflexx and aggressive handling both increased creatine kinase concentrations at slaughter

PRACTICAL APPROACHES TO REDUCE THE RISK OF FATIGUED CATTLE SYNDROME AT THE FEEDLOT

- **Move cattle with a lead rider and perform weigh outs early in the morning during summer months**
- **Identify cattle unfit for transport**
- **Minimize cattle duration spent in transport and lairage**

To learn more about these studies, contact your Elanco technical consultant or sales representative.

The label contains complete use information, including cautions and warnings. Always read, understand and follow the label and use directions.

CAUTION: Not for animals intended for breeding.

Optaflexx: Complete feed
For increased rate of weight gain and improved feed efficiency: Feed 8.2 to 24.6 g/ton of ractopamine hydrochloride (90% DM basis) continuously in a complete feed to provide 70 to 430 mg/hd/d for the last 28 to 42 days on feed.

For increased rate of weight gain, improved feed efficiency and increased carcass leanness: Feed 9.8 to 24.6 g/ton of ractopamine hydrochloride (90% DM basis) continuously in a complete feed to provide 90 to 430 mg/hd/d for the last 28 to 42 days on feed.

Optaflexx: Top dress
For increased rate of weight gain and improved feed efficiency: Feed 70 to 400 mg/hd/d of ractopamine hydrochloride (90% DM basis) continuously in a minimum of 1.0 lb/hd/d top dress Type C medicated feed (maximum 800 g/ton ractopamine hydrochloride) during the last 28 to 42 days on feed.

1Hagenmaier, J.A., Reinhardt, C.D., et al. (2017). Effect of handling intensity at the time of transport for slaughter on physiological response and carcass characteristics in beef cattle fed ractopamine hydrochloride. Journal of Animal Science, 95(5), 1963-1976.
2Hagenmaier, J.A., Reinhardt, C.D., et al. (2017). Effects of ractopamine hydrochloride on growth performance, carcass characteristics, and physiological response to different handling techniques. Journal of Animal Science, 95(5), 1977-1992.
3Edwards-Calloway, L.N., Calvo-Lorenzo, M.S., Scanga, J.A., and Grandin, T. 2017. Mobility Scoring of Finished Cattle. Veterinary Clinics of North America, Food Animal Practice, 33:235-250
4Thomson, D. U., G. H. Loneragan, J. N. Henningson, S. Ensley, and B. Bawa. (2015). Description of a novel fatigue syndrome of finished feedlot cattle following transportation. J. Am. Vet. Med. Assoc. 247:66–72.

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