Inflammatory Modulators Improve Daily Gain of Heat-Stressed Wethers

Micah S. Most
Pablo C. Grijalva
Dustin T. Yates

Summary with Implications

Inflammation during heat stress may mediate poor growth in livestock. The effects of anti-inflammatory treatments on muscle growth during chronic heat stress were evaluated by using meat lambs as a smaller, cheaper model for feedlot steers. Wethers were maintained in normal (75°F) or heat stress (105°F for 12 hours/day, 85°F for 12 hours/day) environments for 30 days and received dexamethasone injections every 3 days, oral fish oil supplementation twice daily, or no intervention. Growth was tracked and muscles were weighed when harvested afterward. Dexamethasone and fish oil both increased average daily gain over the final 15 days of the study despite no difference in feed intakes. In general, heat stress reduced muscle weights. Dexamethasone recovered size deficits caused by heat stress for many but not all muscles. Fish oil supplementation also rescued size in some muscles but was less profound than dexamethasone. Nevertheless, these results show that targeting inflammation may be key to improving muscle growth in heat-stressed livestock.

Introduction

Chronic heat stress impairs muscle growth in livestock and costs producers in the beef industry an average of almost $400 million every year. Misters, shades, and other mechanical means to alleviate heat stress can be difficult and costly to implement. In addition to reducing daily feed intake, recent work by this lab shows heat stress causes systemic inflammation that contributes to deficits in growth. Polyunsaturated fatty acids (PUFA) are found in many food components and reduce inflammation. Dexamethasone is a synthetic version of the hormone cortisol that is widely used to reduce inflammation in sick or injured animals. It is hypothesized that treating with either may have the potential to improve growth outcomes in heat-stressed livestock, but these effects have not yet been characterized. The objective was to determine how dietary supplementation with PUFA-rich fish oil or treatment with injectable dexamethasone would impact daily feed intake, average daily gain, feed efficiency, and muscle growth in feedlot wethers during chronic heat stress.

Table 1. Growth in heat-stressed feedlot wethers administered oral fish oil twice daily or injectable dexamethasone every 3 days for 30 days.

Metric	Experimental Group			
	Control	Heat Stress	Heat Stress + Dexamethasone	Heat Stress + Fish Oil
Avg. Daily Gain (lb)				
Day 0–15	0.59 ± 0.13	0.55 ± 0.07	0.64 ± 0.13	0.37 ± 0.15
Day 15–30	0.31 ± 0.11[a]	0.29 ± 0.11[a]	0.55 ± 0.11[b]	0.66 ± 0.11[b]
Day 0–30	0.42 ± 0.09	0.40 ± 0.09	0.57 ± 0.07	0.53 ± 0.04
Feed Intake (lb/d)				
Day 015	3.35 ± 0.24	3.40 ± 0.24	3.35 ± 0.24	3.44 ± 0.24
Day 15–30	3.31 ± 0.18	3.20 ± 0.18	3.40 ± 0.18	3.11 ± 0.18
Day 0–30	3.33 ± 0.20	3.29 ± 0.20	3.37 ± 0.20	3.26 ± 0.20
Gain:Feed (lb/lb)				
Day 0–15	0.173 ± 0.031	0.161 ± 0.031	0.184 ± 0.031	0.107 ± 0.031
Day 15–30	0.086 ± 0.037[x]	0.076 ± 0.037[x]	0.166 ± 0.037[y]	0.218 ± 0.037[y]
Day 0–30	0.126 ± 0.025[x]	0.114 ± 0.023[x]	0.171 ± 0.008[y]	0.162 ± 0.010[y]

[a,b] Means with different superscripts differ ($P \leq 0.05$).
[x,y] Means with different superscripts tend to differ ($P < 0.10$).
NS, Not significant.

Procedure

Wethers were stratified by bodyweight and randomly assigned to normal (i.e. controls; 75°C for 24 hours/day; n = 10) or heat stress (105°F for 12 hours/day, 85°F for 12 hours/day, 35% relative humidity) conditions for 30 days. Heat-stressed wethers received a) twice-daily oral fish oil capsules (0800 and 1600; 1200 mg, per previous studies in the literature; n = 8), intramuscular dexamethasone injections every three days (2 cc; n = 8), or no intervention (n = 8). Controls were pair-fed to the average intake of heat stressed wethers. Daily feed intake and weekly bodyweights were measured, and wethers were harvested upon completion of the 30-day period. Empty bodyweight was estimated postmortem by removing the digestive tract. Several muscles relevant to carcass composition were collected and weighed.

Table 2. Skeletal muscle size in heat-stressed feedlot wethers administered oral fish oil twice daily or injectable dexamethasone every 3 days for 30 days.

Metric	Experimental Group			
	Control	Heat Stress	Heat Stress + Dexamethasone	Heat Stress + Fish Oil
Muscle Weight (lbs)				
Biceps Femoris	0.89 ± 0.03^{x}	0.81 ± 0.03^{y}	0.89 ± 0.02^{x}	0.88 ± 0.02^{x}
Flexor digitorum superficialis	0.09 ± 0.002	0.09 ± 0.004	0.10 ± 0.004	0.09 ± 0.004
Gastrocnemius	0.29 ± 0.01^{x}	0.28 ± 0.02^{xy}	0.30 ± 0.004^{x}	0.27 ± 0.01^{y}
Longissimus dorsi	1.5 ± 0.1^{x}	1.3 ± 0.1^{y}	1.4 ± 0.1^{xy}	1.3 ± 0.04^{y}
Soleus	0.006 ± 0.001^{a}	0.005 ± 0.0002^{b}	0.006 ± 0.0002^{a}	0.006 ± 0.001^{a}
Semitendinosus	0.32 ± 0.01^{x}	0.29 ± 0.01^{y}	0.30 ± 0.01^{xy}	0.29 ± 0.01^{y}
Mass/Empty BW (g/lbs)				
Biceps Femoris	4.93 ± 0.10^{a}	4.59 ± 0.10^{b}	4.95 ± 0.07^{a}	4.86 ± 0.11^{a}
Flexor digitorum superficialis	0.53 ± 0.01	0.50 ± 0.02	0.56 ± 0.01	0.52 ± 0.02
Gastrocnemius	1.61 ± 0.05^{a}	1.58 ± 0.04^{ab}	1.64 ± 0.03^{a}	1.49 ± 0.04^{b}
Longissimus dorsi	8.1 ± 0.3^{x}	7.5 ± 0.2^{y}	7.6 ± 0.2^{xy}	7.0 ± 0.1^{z}
Soleus	0.037 ± 0.004^{a}	0.025 ± 0.002^{b}	0.030 ± 0.001^{c}	0.035 ± 0.003^{ac}
Semitendinosus	1.77 ± 0.03^{x}	1.68 ± 0.05^{y}	1.64 ± 0.05^{z}	1.64 ± 0.04^{yz}

^{a,b} Means with different superscripts differ ($P \leq 0.05$).

^{x,y} Means with different superscripts tend to differ ($P < 0.10$).

BW, bodyweight; NS, Not significant.

Results

Initial and final bodyweights were not different among groups, but average daily gain was increased ($P < 0.05$) and feed efficiency tended to be increased ($P = 0.06$) over the last 15 days of the study for wethers treated with dexamethasone or fish oil (Table 1). Moreover, feed efficiency tended to be greater ($P = 0.10$) for wethers treated with dexamethasone or fish oil across the entire 30-d period. Heat stress decreased ($P < 0.05$) the size of the soleus muscle and tended to decrease ($P < 0.10$) the size of the biceps femoris, longissimus dorsi, and semitendinosus muscles (Table 2). Injection with dexamethasone every 3rd day improved the size deficits caused by heat stress for the biceps femoris (upper hindlimb), gastrocnemius (lower hindlimb), longissimus dorsi (loin), and soleus (lower hindlimb) muscles but did not recover size deficits in the semitendinosus (upper hindlimb) muscle. Twice-daily oral supplementation of fish oil improved ($P < 0.05$) size deficits caused by heat stress for biceps femoris and soleus muscles.

Conclusions

From these findings, we conclude that although chronic heat stress in growing livestock diminished indicators of muscle growth, treating heat-stressed animals with anti-inflammatory agents improved many of these indicators. Indeed, the improved size of multiple muscles in heat-stressed lambs treated with dexamethasone or fish oil support the hypothesis that anti-inflammatory pharmaceuticals and nutritional compounds rescue muscle growth during heat stress. Continued investigation of the biological processes underlying these improvements will provide the basis for nutritional, supplemental, and pharmaceutical strategies to recover performance in heat-stressed livestock.

Micah S. Most, graduate student

Pablo C. Grijalva, graduate student

Dustin T. Yates, Associate Professor, Animal Science, University of Nebraska-Lincoln