INVITED PAPER: Nutritional and management considerations for beef cattle experiencing stress-induced inflammation

R. F. Cooke

Eastern Oregon Agricultural Research Center, Oregon State University, Burns 97720

ABSTRACT

Beef cattle are exposed to several stressors when relocated from cow-calf ranches to feedlots, including transport and feedlot entry. These events elicit a myriad of stressors that increase \((P < 0.05)\) plasma concentrations of pro-inflammatory cytokines and acute-phase proteins (APP), and the magnitude of the APP response during feedlot receiving was negatively correlated \((r = -0.50, P < 0.01)\) with ADG and DMI. Hence, strategies to decrease the stress-induced APP response during feedlot receiving were investigated. In Exp. 1, steers were assigned to continuous road transport for 1,290 km, or road transport for 1,290 km with rest stops every 430 km. Inclusion of rest stops decreased \((P \leq 0.04)\) plasma APP concentrations on d 1 of feedlot receiving but did not increase receiving \((P > 0.68)\) ADG and G:F. In Exp. 2, steers received or not Ca-soaps of soybean oil during a 28-d preconditioning and then were transported for 24 h. Supplemented steers had less \((P < 0.01)\) plasma concentrations of tumor necrosis factor-α and greater \((P = 0.02)\) ADG during feedlot receiving. In Exp. 3 and 4, respectively, steers were transported and administered flunixin meglumine at truck loading and unloading \((1,280-km\) transport) or meloxicam at loading and during the initial 7 d of receiving \((1,440-km\) transport). Both treatments decreased \((P < 0.05)\) the APP response during feedlot receiving, but only meloxicam increased \((P < 0.04)\) receiving ADG and G:F. Therefore, inclusion of rest stops during transport, supplementing essential fatty acids during preconditioning, and administering nonsteroidal anti-inflammatory drugs are methods to decrease the stress-induced APP response during feedlot receiving, whereas essential fatty acids and meloxicam enhanced receiving performance.

Key words: beef cattle, inflammation, management, nutrition, stress

INTRODUCTION

“Stress response” is commonly defined as the sum of all reactions of an individual to factors that potentially influence its homeostasis (Moberg, 2000). The foundation for this concept emerged more than 70 yr ago, when stress was first employed in the medical community by Hans Selye, who also proposed that an organism responds similarly to different types of stressors in an effort to maintain homeostasis (Selye, 1973). Although the physiologic consequences of stress are still not fully elucidated (Pacak and Palkovits, 2001), it has been demonstrated that stressors affect the immune system, as well as different responses within the body, mainly via the hypothalamic-pituitary-adrenal (HPA) axis and the sympathetic nervous system (Elenkov et al., 2000).

Beef cattle are inevitably exposed to stress during their productive lives (Carroll and Forsberg, 2007). These include psychologic, physiologic, and physical stressors associated with management procedures currently practiced within beef production systems. A classic example occurs during transfer of beef calves from cow-calf ranches to commercial feedlots, when cattle are exposed to several stressors within a short period of time (Araujo et al., 2010). These include weaning, commingling with different animals, and exposure to novel environments (psychologic stressors), injury, thermal stress, fatigue, feed and water deprivation during road transport (physical stress), as well as the resultant disruption in endocrine or neuroendocrine function (physiologic stress) characterized by activation of the HPA axis (Carroll and Forsberg, 2007).

The combination of some or all of the aforementioned stressors has been shown to directly decrease cattle performance and increase risk to bovine respiratory disease complex (Duff and Galvean, 2007). This complex, often composed of viral, bacterial, and mycoplasmal infections (Ellis, 2001), is the most common and costly disease of feedlot cattle in the United States (NASS, 2006). Such economical losses include, besides cattle mortality, costs associated with wasted feed resources, purchase of pharmaceuticals, and decreased performance of morbid cattle (Loerch and Fluharty, 1999). Hence, strategies that prevent stress-related health disorders elicited by routine cattle management procedures are warranted to promote beef cattle welfare and productivity.
Elevated cortisol is one of the main outcomes of the HPA activation, independent of whether the stressor is from psychological, physiological, or physical nature (Crookshank et al., 1979; de Kloet et al., 2005; Carroll et al., 2009). This is the reason why cortisol is generally considered the paramount to the neuroendocrine stress response (Sapolsky et al., 2000) and also a major link between stress and immune function (Glaser and Kiecolt-Glaser, 2005). During episodes of chronic stress, sustained increases in circulating cortisol promote an anti-inflammatory and immunosuppressive response, mainly by decreasing synthesis of proinflammatory cytokines by immune cells (Kelley, 1988). Conversely, sharp increases in circulating cortisol, such as during acute stress, have been shown to elicit a temporary immune response, more specifically an inflammatory reaction. Our research group was the first to report transient increases in proinflammatory cytokines in overtly healthy beef cattle during feedlot receiving (Cooke et al., 2011b), as well as in beef cattle receiving i.v. infusion of corticotrophin-release hormone as a model to stimulate the HPA axis (Cooke et al., 2012b). These results indicate that, besides their recognized immunosuppressive potential, stressors can also activate the innate immune system.

![Figure 1](image-url)

**Figure 1.** Plasma cortisol (ng/mL), serum nonesterified fatty acids (NEFA; μEq/L), and plasma ceruloplasmin (mg/dL) concentrations during a 28-d feedlot receiving period in cattle subjected to 24-h transport for 1,200 km (TRANS), no transport but feed and water deprivation for 24 h (RSTR), or no transport and full access to feed and water (CON). Treatments were concurrently applied from d 0 to 1. Within days, letters indicate the following treatment differences ($P \leq 0.05$): a = TRANS vs. CON, b = RSTR vs. CON, c = TRANS vs. RSTR. Error bars indicate SE. Adapted from Marques et al. (2012).
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