Post-weaning, Feedyard, and Carcass Performance of Alabama Feeder Cattle: The Current State of Alabama Cattle and the Effect of Backgrounding Diet

by

Daniel Alexander Tigue

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Retained Ownership, Backgrounding, Transportation Stress

Approved by

Dr. Christy Bratcher, Associate Dean of Research Texas Tech University
Dr. Kim Mullenix, Associate Professor Department of Animal Science
Dr. Soren Rodning, Professor Department of Animal Science
Dr. Jessica Starkey, Associate Professor Department of Poultry Science

Abstract

Understanding the effect of post-weaning management strategies on feedyard performance, health, and carcass characteristics of Southeastern beef calves can help cattle producers add value to their operations. However, due to the segmentation of the beef industry in the U.S., feedback from processing facilities and feedyards is rarely received by cow-calf producers that make many management decisions that impact the performance of cattle during those later stages. In an attempt to help producers receive that feedback in the form of performance, health, and carcass data, the Alabama Cooperative Extension System operates the Alabama Pasture to Rail Program (P2R). P2R is a retained ownership program in which cattlemen across Alabama can feed small groups of cattle in a southern plains feedyard and receive all data back on each of their animals, allowing them to make changes to their management programs to improve cattle health and performance. In total, 2,188 calves from 73 farms were consigned and shipped from October 2016 through March 2020. Performance data, carcass characteristics, and profitability metrics were compared by year, by sex, and by health outcome using the PROC GLIMMIX feature of SAS 9.4 (SAS Institute, Cary, NC). Additionally, a stepwise regression was conducted to determine which factors had the greatest impact on profitability. This was conducted using PROC REG feature of SAS 9.4 (SAS Institute, Cary, NC). Additionally, Pearson Correlation Coefficients were used to confirm relationships seen this stepwise regression. Differences in carcass characteristics, growth performance, and profitability were observed ($P < 0.05$) by year and sex. To understand the effect of backgrounding diet on transportation stress, feedyard adaptation, feedyard performance, and carcass merit, two studies were conducted over the course of two years. Steers and heifers from the E.V. Smith Research Center (Shorter, AL) were subjected to a 60 d backgrounding trial. In

year 1, calves were assigned to one of four dietary treatments: cool-season baleage with supplemental dried distiller's grains with solubles (DDGS), bermudagrass hay with supplemental DDGS, grazing crabgrass/signalgrass pastures with supplemental DDGS, and grazing crabgrass/signalgrass pastures with no supplemental feed. In year 2, calves were assigned to one of four dietary treatments: cool-season baleage with supplemental DDGS, cool-season baleage with supplemental commercial commodity feed, cool-season baleage with no supplemental feed, and bermudagrass hay with supplemental DDGS. In both years, differences between supplemented groups were minimal during the backgrounding period and in the feedyard. Groups that did not receive supplemental feed had reduced performance during backgrounding, but differences between supplemented groups and non-supplemented groups during the feedyard period and at harvest were minimal.

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List of Abbreviations

ADG   Average Daily Gain

ARS   Agricultural Research Service

BF   Backfat Thickness

BS   Baleage plus supplemental feed

BW   Body Weight

CBC   Complete Blood Count

CDC   Centers for Disease Control and Prevention

DOF   Days on Feed

GO   Grazing Only

GS   Grazing plus supplemental feed

HGB   Hemoglobin Concentration

HCW   Hot Carcass Weight

HCT   Hematocrit percentage

HPA   Hypothalamic-Pituitary-Adrenal Axis

HS   Hay plus supplemental feed

IACUC   Institutional Animal Care and Use Committee

IFNγ   Interferon-γ

IL-6   Interleukin-6

LYM   Lymphocyte Concentration

NEU   Neutrophil Concentration

N:L   Neutrophil to Lymphocyte Ratio

P2R   Alabama Pasture to Rail Program

QG	USDA Quality Grade
RBC	Red Blood Cell Count
REA	Ribeye Area
RV	Rappaport Vassiliadis
TSB	Tryptic Soy Broth
TSI	Triple Sugar Iron Slant
TT	Tetrathionate Broth
USDA	United States Department of Agriculture
WBC	White Blood Cell Count
YG	USDA Yield Grade
XLT4	Xylose Lysine Tergitol-4

<u>**Chapter I: Review of Literature**</u>

<u>**Introduction**</u>

Modern beef industry in the United States is an industry that is heavily segmented. In general, the live production of beef cattle is broken into three major segments: the cow-calf sector, the stocker/backgrounder sector, and the cattle feeding/finishing industry (Field et al., 2016). Each of these sectors plays a vital role in the industry. The cow-calf sector is the predominant production system in the southeastern U.S., where producers utilize mature cows for the production of calves that are usually sold at weaning (Ball et al., 2015). The stocker/backgrounder sector, typically, takes these light weight calves, feeds them to increase their size, upgrades their health status, and prepares them for the feeding/finishing phase. This sector has a vitally important role in helping the U.S. beef industry realize its competitive advantage of utilizing forage resources to provide an economic way of adjusting timing and volume of cattle that enter the feedyard (Peel, 2003).

The terminology during this portion of the beef supply chain can be quite regionalized and confusing with overlapping usage of a few common terms. "Stocker" and "Backgrounding" operations are largely used as synonymous terms to describe enterprises that focus on post-weaning animal growth, enhancing animal weight, age, maturity, and quality (Peel, 2003). "Stocker" tends to be more southern U.S. term, where "Backgrounding" tends to be used to describe similar operations in the northern U.S. and other areas (Peel, 2003). "Preconditioning" is generally used as a term to describe the weaning, vaccination, and nutritional adaptation of calves at the cow-calf operation of origin (Lardy, 1998; Lalman, et al. 2010). Historically, this would has for a short period (45 days or less) (Peterson et al., 1989; Lardy, 1998; Pate, et al.

2002), but recommendations for preconditioning periods are shifting toward 60 days or greater (Wells et al., 2019).

<div align="center">**<u>Post-weaning Management of Beef Cattle</u>**</div>

<u>Nutrition</u>

Growth and performance of calves during this phase is a major component to a backgrounding or preconditioning program for feeder calves (Cole, 1985). For a cow-calf producer looking to wean and precondition their calfcrop, nutrition can be 50 to 70% of the total budget for preconditioning calves (Lalman et al., 2010).The goal during this phase of the beef industry is the development of animal frame and muscle in preparation for finishing in the feedyard, largely using forage resources with or without the supplementation of concentrate feeds (Peel, 2003).

Grazing crabgrass as part of backgrounding diets

When determining how to utilize forage resources in backgrounding system, especially for fall-born calves which must be weaned in the late spring to early summer, grazing warm-season forages is logical. Warm season grass systems can provide high yields of good quality forage for short periods during the summer (Hancock et al., 2011). This is especially advantageous for producers that rely on tall fescue and other cool-season forages for the base of their system (Tracy et al., 2010).

However, grazing growing animals during this time can be quite challenging. Because of the relatively short growing season (especially in the mid-South) and high establishment cost, grazing warm season grasses can have tight returns and profits with one study showing perennial forages, specifically bermudagrass and several native warm-season grass species, outperforming crabgrass (Boyer et al., 2019). Boyer et al. (2019) demonstrated this by grazing several warm-

season forages at two location in Tennessee. At one location, Crabgrass created similar gain per acre compared to Bermudagrass, but not at the other location (Boyer et al., 2019). At both locations Warm-season Native Grasses (Switchgrass, Eastern gamagrass, and a Big Bluestem/Indiangrass mix) generate greater gains per acre than the crabgrass (Boyer et al., 2019). Additionally, with increased drought potential during the summer months in the Southeast, warm-season annuals have an enhanced risk of stand failure even under optimal management (Harmon et al., 2019).

Crabgrass is considered a weed in turfgrass, perennial grass hayfields, and most other agronomic crops (Ogden et al., 2005), however it has long been an important forage crop in the United States. Crabgrass was introduced into the U.S. in 1849 (Andrae, 2002). "Crabgrass hay" was mentioned as being used in experiments for feeding beef cattle in Mississippi as early as the 1890's (Lloyd, 1896). The Noble Foundation has been developing and utilizing crabgrass as a hay and grazing crop since at least the 1970's (Dalrymple, 1980), and released the first improved variety, "Red River", in 1988 (Blount et al., 2003)

Crabgrass can be very productive in terms of growth, as well as high in nutritive value. Ogden et al., (2005) demonstrated that crude protein ranged from 15.9-21.0% throughout July and August, with neutral detergent fiber never exceeding 61.9% and acid detergent fiber 31.2%, with no harvest and, in turn, regrowth. Other data by Teutsch et al. (2005) indicates *in vitro* digestibility of crabgrass can regularly exceed 80% through the middle of the growing season (August in Virginia), but clearly declines over time. Beck et al., (2007) analyzed the change in forage mass and nutritive quality of crabgrass at 21, 35, and 49 d harvest intervals. As might be expected, forage mass increased and quality decreased with greater harvest interval lengths, suggesting that this forage should be managed intensely with grazing or hay production to

maintain forage quality while maximizing yield potential. Additionally, when included in mixtures, crabgrass can act as insurance against stand failure. Harmon et al., (2019) conducted a study to utilize different warm-season annuals to finish beef cattle. In each of the three years, the mixture that included crabgrass had the greatest percentage of desirable species in the plots each time point, and saw very little change from early sample dates through completion of the study compared to pure stands of other warm-season annual forages. This could be interpreted as a sign of Crabgrass's ease of establishment and growth potential when compared with other warm-season annual forages in the same environment and management.

Despite multiple examples of the quality of crabgrass as a forage, research into its use as a grazing option in backgrounding diets is limited. In wheat pasture grazing systems, crabgrass can be used to "double crop" these prepared seedbeds and add to the grazing season throughout the summer (Warren et al., 2018). In this scenario, grazing crabgrass without supplementation has been shown to support animal gains of 0.56-0.90 kg/d during grazing seasons of 98-120 days with 146-269 kg of gain per hectare (Lomas et al., 2003), however this was with long-time weaned, older stocker cattle and may not be directly translatable to backgrounding or preconditioning younger, newly weaned calves of at their farm of birth. Stocker gains from a study in Tennessee were similar at 148-275 kg of gain per hectare (Boyer et al., 2019). Research in the area of grazing crabgrass is needed to keep pace with industry utilization of this forage crop.

Use of ensiled cool-season annual forages in backgrounding diets

Baled silage, commonly referred to as "baleage", is a forage harvest and storage method that gives forage producers another option to conserve forages at optimum quantity and forage quality (Hancock et al., 2019). This has become increasingly popular in the Southeast, as it

allows forage producers to use conventional forage harvesting equipment to cut, condition, and

bale forage at 40 to 60% moisture, before it is wrapped in plastic in a specialized bale-wrapper,

as compared to conventional silage that requires very specialized harvest equipment and storage

facilities that are not common in beef cattle operations in the south (Ball et al., 2015). The ability

to bale and store forage at relatively high moisture content is also attractive as it allows

producers to harvest high quality forages when erratic weather conditions can make field curing

of dry hay difficult (Han et al., 2014).

Baleage, like all other types of ensiled feedstuffs, preserves forage through anaerobic

fermentation. In the first few hours after harvest and storage, atmospheric oxygen is reduced by

plant respiration and microbial activity of aerobic and facultative aerobic microorganisms, like

yeasts and enterobacteria (Elferink et al., 2000). As this occurs, the silage slowly creates an

anaerobic environment which allows lactic acid bacteria to become the predominant microbial

population (Elferink et al., 2000). Generally it is accepted that the resulting lactic acid production

from these anaerobic microoganisms will lower the pH to less than 4.5, which should limit the

growth of molds and other spoilage organisms (Dillard et al., 2018), but there are some

discrepancies in the literature showing that ultimate pH during the stable phase to be as low as

3.6 and as high as 5.2, depending on forage type, moisture, and many other factors (Elferink et

al., 2000; Ball et al., 2015; Lemus et al., 2017). Additionally, because forage that is baled for

baleage can have greater particle length, poor availability of fermentable carbohydrates, and low

bale density allowing greater residual oxygen, baleage systems can sometimes struggle to

achieve optimum fermentation when compared to traditional chopped grass silage (McCormick,

2013).

Moisture content is crucial in baleage production. Generally recommendations are to wrap bales at 40-60% moisture for optimum fermentation (Ball et al., 2015; Lemus et al., 2017; Dillard et al., 2018). When baleage is stored below 30% moisture, there isn't enough moisture for proper fermentation to occur (Lemus et al., 2017). High moisture content can lead to undesirable bacteria proliferating and producing butyric acid, which creates a foul odor in the resulting silage (Ball et al., 2015).

Martin et al., (2015) conducted a study to evaluate the differences in bermudagrass hay, bermudagrass baleage, and ryegrass-rye baleage with supplemental liquid feed as backgrounding rations for spring-born beef calves. The bermudagrass hay and baleage was of similar maturity and forage quality with the ryegrass-rye baleage having slightly increased total digestible nutrients (TDN). The two bermudagrass treatments did not result in differences in body weights of weaned calves after a 60 d backgrounding period, which would indicate that simply ensiling forage does not improve nor reduce performance of beef calves during the backgrounding period. Calves fed ryegrass-rye baleage were heavier and had greater body weight gain than the bermudagrass treatments. This data agrees with Forte et al., (2018) that cool-season annual forage baleage can be an effective forage base for backgrounding diets.

Research investigating the use of baleage in backgrounding beef calves is limited, however some additional data exists surrounding more traditional grass silage. Blom et al., (2020) evaluated differences in oat hay, dampened oat hay, and oat silage as part of a mixed ration in drylots for a 42 d backgrounding study over two years. Similar to the study by Martin, overall growth performance was not effected by forage conservation and feeding method, however they did see a reduction in feed efficiency in the calves fed baleage for one of the two years of the study. Adewakun et al., (1989) demonstrated that sorghum silage could be harvested

that would equal corn silage in terms of nutritive value and performance characteristics in weaned beef calves, which is also similar to result from Forte et al., (2018) in terms of using grass silage/baleage to replace traditional corn silage. With a continually growing interest in baleage production, further research will be vital to understanding role it can play as a forage option for growing beef calves, as well as any limitations and advantages it might present for cattlemen.

Supplementation in backgrounding diets

Profitability for stocker and backgrounding systems largely depends on performance and achieving gains of at least 0.68 kg/d, requiring calves to consume a diet that contains at least 12% crude protein and is at least 65% digestible (Ball et al., 2015). For short preconditioning and backgrounding programs of 45-75 d, additional gains may be required to meet cattle weight targets for marketing purposes of cattle producers and the use of supplemental feedstuffs is warranted (Moore et al., 1999). Energy and/or protein supplementation in forage-based growing systems is common in these operations to achieve these elevated rates of gain and compensate for changes in forage quality and availability (Drouillard et al., 1999).

In 1999, Moore et al., (1999) published an extensive review of the literature and meta-analysis of 66 published articles that studies various forage systems with supplementation of energy and/or protein feedstuffs, and the resulting performance in non-lactating beef cattle. Interestingly, the authors noted that the inclusion of supplemental feed did not always increase average daily gain in cattle and the supplemental energy (total digestible nutrients, TDN) was not closely related to the change in average daily gain. The smallest increases in gains occurred in studies supplementing native forages with molasses alone or molasses with non-protein nitrogen sources (Moore et al., 1999). The greatest increases in cattle performance were with improved

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forage species, high energy supplemental feeds (>60% TDN), and increased crude protein intake (>0.05% BW) (Moore et al., 1999). The researchers' primary goal was to better understand the associative (non-additive) effects of supplemental feeds fed in a restrictive manner when forage intake was voluntary and unlimited (Moore et al., 1999). Generally, it appears that when protein is not limiting the underlying forage system, supplementation usually decreases forage intake. However, this data appears to suggest that this is not simply a 1:1 substitution effect, but much more complex. When supplemental feed provided at least 0.7% BW of TDN, forage intake was always decreased, but again it is not indicated by the authors if this decrease is a 1:1 decrease of forage TDN to the increase in supplemental TDN. Inversely, when forages were limited by protein content, supplemental feed increases forage intake. Clearly, Moore et al. (1999) demonstrates that the interaction between supplemental feeding options and the base forage program in an operation is a complicated one, with both additive and deleterious associative effects seen. These were not well understood at the time this was published and are likely still not well defined in the literature for every forage system and supplemental feeding strategy.

Since that meta-analysis was published, there has been an abundance of research focused in the area of protein and energy supplementation of growing beef cattle in forage-based systems. Wickersham et al., (2008a) utilized casein as a protein source at 4 increasing concentrations that were dosed directly into the rumen of 5 ruminally fistulated steers. Casein was selected because of its high concentration of rumen degradable protein and lack of carbohydrates. Increasing protein in the rumen linearly increased forage intake of a relatively low quality forage (4.9% CP, 72.3% NDF, 42.9% ADF). The authors also measured a significant linear shift in volatile-fatty acid production, with less acetate and greater propionate in the high protein treatments. In an additional study, these same authors demonstrated that supplementation

of rumen undergradable protein also resulted in the increased intake of forage organic matter, but had no effect on rumen acetate production and a much more limited effect on propionate concentration (Wickersham et al., 2008b). The effect of increasing forage intake with increasing levels of protein supplementation agrees with other published work (Lopes et al., 2014; Sotelo et al., 2018). Batista et al., (2016) reported the same numeric trend, but it was not significant. Bohnert et al., (2011) showed an increase in forage intake in supplemented groups versus control which is in contrast to others, but also noted an increase in intake of a C3 forage (Kentucky Bluegrass) over a C4 (tallgrass prairie hay) of similar quality.

In addition to nutritive value, purchase price of feed ingredients is incredibly important in stocker and backgrounding systems. In an effort to manage this, the use of by-product or co-product feed ingredients has been in common in the Southeast for many years where many different types are produced (Rankins and Prevatt, 2013). By-product or co-product feeds can be defined as feed ingredients that are produced as secondary products in the processing of many crops (Mullenix and Rankins, 2018). In Alabama, by-product feeds are commonly found from the ginning of cotton, processing of peanuts, extraction of oil from soybeans, wheat milling, dry and wet milling of corn, citrus production, and the fermentation of grains for alcohol (Mullenix and Rankins, 2018). By-products from each of these can be used in cattle diets to meet protein, energy, and/or fiber needs. For example, soybean hulls are a commonly used co-product feed that has been shown to effectively have the same feeding value as corn when supplemented at low rates with forage-based diets and is more effective than corn when fed at 1% of body weight or greater, likely due to its high fiber content and positive effect on forage digestibility (Garces-Yepez et al., 1997).

Spent distiller's grains have become a popular co-product feed ingredient throughout the beef industry with the increase in fuel ethanol production. Distiller's grains are the co-product of the fermentation of corn, wheat, or other grains for the production of ethanol and are sold in many forms such as wet distiller's grains, dry distiller's grains, wet distiller's grains with solubles, and dry distiller's grains with solubles (DDGS) (Hoffman et al., 2011). Distiller's grains can be an excellent feedstuff to provide both protein and energy for cattle producers, exceeding 30% crude protein and containing similar energy values to corn (Wahrmund et al., 2011). However, distiller's grains can present some challenges in consistency like many co-product feeds. Overheating during the manufacturing process can damage a portion of the protein fraction, making it unavailable to animals (Kleinschmidt et al., 2006). Additionally, sulfuric acid is added during fermentation to adjust pH to optimize ethanol yield, which increases sulfur content of the resulting co-product feed (Uwituze et al., 2011). When fed as a large portion of the total diet (50% in one study), sulfur content in DDGS has been shown to cause sulfur toxicity issues in growing cattle including polioencephalomalacia and death (Buckner et al., 2007), as well as potentially reducing fiber digestibility (Uwituze et al., 2011).

DDGS has relatively high fat content and percentage of rumen undegradable intake protein (UIP) (Kleinschmidt, et al. 2006). Loy et al., (2008) demonstrated that when supplementing forage-based diets with DDGS at a low rate (0.21% of BW), it effectively had 130% of the energy value of dry rolled corn. At a high rate of supplementation (0.81% of BW), that is reduced to 118% of the energy value of dry rolled corn. This could indicate that DDGS can be a good source of energy in forage-based systems, but might be less effective at greater rates of inclusion in the diet as the energy derived from fat and the UIP are not utilized in the microbial degradation of forages in the rumen.

Morris et al., (2005) supplemented low and high quality forages with varying amounts of DDGS. In both low and high quality forage systems, supplementation of DDGS up to at least 1% of BW was profitable in ~286 kg heifer calves. Additionally, this research indicated that supplementation of DDGS in the diet did not create a dietary substitution effect. For every kg of DDGS fed, heifers ate 0.53 kg less of the high quality forage and 0.33 kg of the low quality forage. While forage utilization or *in situ* digestibility was not directly measured, one could assume that forage digestibility might have been enhanced as total dry matter intake increased as DDGS intake increased. Smith, et al. (2020) measured a similar associative effect on forage utilization when supplementing calves grazing Tifton 85 bermudagrass with various levels of DDGS.

Effects of backgrounding diet on feedyard performance and carcass traits

Nutrition is not only important for performance and weight gain during the backgrounding phase, but also because of potential effects on the subsequent performance of animals during the finishing period and any lasting effects on carcass characteristics. However, there is no clear consensus in the literature about these effects.

In 2014, Lancaster et al. published a meta-analysis of 40 different published articles that highlighted data from 50 experiments dating back to 1970. This analysis compared several aspects of each study including nutrition and animal management on performance during the post-weaning phase as well as subsequent performance in the finishing phase and carcass characteristics. The authors concluded that the level of dietary starch in the backgrounding diet had no effect on feedyard performance. Furthermore, ADG during the backgrounding period did have an effect on feedyard ADG, feed intake, hot carcass weight, ribeye area, and KPH, but not marbling (Lancaster et al., 2014).

When analyzing some individual studies, results are varied. Cox-O'Neill, et al. (2017) observed differences in feed efficiency, ADG, HCW, 12th-rib fat thickness, REA, marbling score, and percent USDA Choice when comparing calves backgrounded in drylots, on cover-crop grazing, or grazing corn residue with supplemental feed. In this study, calves exited the growing phase with differences in body weight and ADG during backgrounding, which might explain the differences observed in feedyard performance, with the cattle that were heavier at feedyard entry outperforming their lighter counterparts. Cox-O'Neill et al. (2017) agree with other studies looking at similar systems (Choat et al., 2003; Hersom et al., 2004). Other studies that used various backgrounding diets that included grazing, crop residues, and/or drylot rations that had little or no difference in growth and performance during the backgrounding phase reported no differences in feedyard performance or carcass traits (Kumar et al., 2012; McMillan et al., 2018).

Outside of the Lancaster et al. (2014) meta-analysis, none of the previously described studies or data are from the southeast US or even in similar forage systems to those prevalent in the region. Most are in Midwestern or Great Plains environments, observing spring-born calves that are backgrounded through the winter months. Additionally, only 2 of the citations listed by Lancaster et al. (2014) were studies conducted in the southeast US (Arkansas and South Carolina). This potentially limits any conclusions that can be drawn from the literature about the effect of southeastern warm-season forage systems for fall-born calves, and how they affect feedyard performance and carcass merit.

Smith et al., (2020) fed various levels of DDGS to stocker cattle grazing Tifton 85 bermudagrass and observed no differences in HCW, Calculated YG, REA, or Marbling Score, but did observe differences in feedyard ADG and 12th rib fat thickness after the subsequent

feedyard finishing period. However, the differences in the means for marbling score were similar to previous described studies, so the lack of differences might be due to within group variation and relatively small sample size (n = 112). Differences in ADG during the feedyard phase offset the differences in initial body weight at feedyard arrival to allow for similar finish weights and HCW.

Stress Response, Immune Function and Transportation Stress in Beef Cattle

The definition of stress is somewhat vague, and has changed over time. Generally, stress can be defined the "concerted adjustment of several biological/physiological functions" to actions (stressors) that threaten, perceive to threaten, the homeostasis of animals (Chrousos et al., 2005; Charmandari et al., 2005). In his article in *Nature,* Hans Selye (1936) described the basics of the body's response to these threats as, first, the "general alarm reaction" to alert the organism to a critical situation, then the "general adaptation syndrome", as the body works adapt to the new conditions it is presented with.

Stress in an inherent part of livestock production. Regardless of how careful and well-prepared livestock producers are, stress will occur during the lives of the animals in their care. Comingling, weaning, transportation, social disruption, temperature and climate change, nutritional change, and many other stressors occur daily in livestock production. Transportation is an especially important stressor, as a large percentage of cattle are fed in the Plains states and Midwestern States, while calves are born and raised to weaning in every state. Stress is generally considered to suppress the immune system of the effected animal, potentially leading to disease (Salak-Johnson and McGlone, 2007). Additionally, it has been widely proven that cattle that become sick and are treated for disease see a reduction in animal performance and profitability in the feedyard (Busby et al., 2004; Irsik et al., 2006; Holland et al., 2010). Better understanding

stress and the role it plays with the immune system, as well as the factors that effect that interaction, is critical to increasing efficiency and sustainability of livestock production.

Review of Physiologic Response to Stress

Stressors, like those described earlier, elicit a coordinated, physiologic response to return the body to homeostasis (Carroll and Forsberg, 2007).The Hypothalamic-pituitary-adrenal (HPA) axis and the systemic/adrenomedullary sympathetic nervous system (SNS) make up the controlling portion of the stress response system (Carroll and Forsberg, 2007; Elenkov and Chrousos, 2002.). This system is activated by multiple signals sent from the central nervous system (Elenkov and Chrousos, 2002.). When stress occurs, corticotropin-releasing hormone (CRH) and vasopressin (VP) are secreted by the hypothalamus stimulating the release of adrenocorticotropic hormone (ACTH) from the anterior pituitary gland. ACTH (and to a lesser degree CRH and VP) then stimulates the adrenal cortex to produce glucocorticoids, while at the same time catecholamines are produced in the adrenal medulla (Carroll and Forsberg, 2007.). Glucocorticoids have many effects on the body and are active in several functions such as metabolism, growth, reproduction, the regulation of stress response, influence on the immune system, and enhance the synthesis and secretion of catecholamines (Carroll and Forsberg, 2007).

The cascade of events in the HPA axis is highly regulated at each step, showing that stressors do not elicit an equal "all or none" response. CRH and VP may act together to control the level of the glucocorticoid response and different stressor types elicit response with this signaling hormones in different amounts as well as with other hormones that can signal ACTH synthesis as well, such as oxytocin (Carroll and Forsberg, 2007; Salak-Johnson and McGlone, 2007).

Immune System

The immune system is general broken down into two sections: innate immunity and acquired immunity (Carroll and Forsberg, 2007). The innate immune system is that which combats immediately in the first 0 to 4 hours after introduction of a pathogen, and includes physical barriers, such as the skin, as well as cellular components (Carroll and Forsberg, 2007). Acquired immunity is the portion of the immune system that adapts and builds a response for each adulterant it encounters (Salak-Johnson and McGlone, 2007).

In addition to the physical barriers in the innate immune system, the cellular component of the innate immune system is made up of phagocytic cells such as neutrophils, monocytes, and macrophages as well as natural killer cells and cells that release inflammatory mediators. These recognize a handful of common structures and not every individual potent pathogen (Carroll and Forsberg, 2007). Macrophages and dendritic cells of the innate immune system initiate the acquired immune system by presenting antigens to naïve lymphocytes (Salak-Johnson and McGlone, 2007). Additionally, innate immunity and the release of proinflammatory cytokines from NK cells controls the acute phase response, generating fever as well as acute phase proteins and some additional physiological changes (Carroll and Forsberg, 2007).

Acquired immunity is generally broken down into two categories: cell mediated or humoral (Carroll and Forsberg, 2007). Cell mediated immunity works directly against pathogen-infected cells, while humoral immunity generates specific antibodies for a pathogen. Both pathways involve white blood cells known as lymphocytes (Carroll and Forsberg, 2007). Within the lymphocyte population there are B cells, which produce antibodies and attach to specific antigens, and T cells. Two types of T cell exist: T-helper cells, which secrete cytokines that help other T and B cells grow and divide, and cytotoxic T-lymphocytes, which destroy pathogen-infected cells (Carroll and Forsberg, 2007).

The two types of T-helper lymphocytes direct the acquired immune system to primarily cellular (TH1) or humoral (TH2) immunity (Carroll and Forsberg, 2007). T-helper lymphocytes are also differentiated by the cytokines they produce. TH1 Cells typically produce IL-2, IFN-γ, TNF-β, while TH2 cells are those that typically produce IL-4, IL-5, IL-6, and IL-13. These cytokines both serve as the lymphocytes own autocrine growth factor, but also to downregulate the development and activity of the opposite T-helper lymphocyte type when recruitment of naïve T-lymphocytes occurs (Abbas, et. al., 1996.).

Response to Stress in the Immune System

Stress can have a negative or positive effect on the immune system. Short term or acute stress can have an immune-enhancing effect, while it is thought that chronic stress can have an immune-suppressing effect (Carroll and Forsberg, 2007). Hans Selye (1936) was the first to elucidate three stages of what would now be called chronic stress: 1. Decrease in size of the thymus, spleen, lymph glands, and liver 2. Adrenal enlargement 3. Exhaustion.

Glucocorticoids and catecholamines produced during the reaction to stress have an effect on CD4+ T lymphocyte differentiation. Antigen-producing cells would produce IL-12 and TNF-α to stimulate TH1 production or IL-10 for TH2. Glucocorticoids and catecholamines both downregulate IL-12 production, while also upregulating IL-10 production, shifting the differentiation of naïve T lymphocytes to TH2 (Elenkov and Chrousos, 2002; Salak-Johnson and McGlone, 2007). A strong bias toward TH2 or humoral immunity may interfere with viral clearance in the case of a viral infection (Salak-Johnson and McGlone, 2007; Bot et al., 2004). A precisely regulated balance of TH1 and TH2 cells is required for optimal recovery from a viral infection (Bot et al., 2004).

Glucocorticoids provide a negative feedback loop on cytokine gene expression (Carroll and Forsberg, 2007), but there is evidence to suggest that a reduction in glucocorticoid sensitivity might alter this negative feedback loop. Miller, et al. (2002), studied chronic psychological stress in parent of children undergoing cancer treatment. What they found was that in whole blood drawn from these highly stressed parents dexamethasone did not cause the same responsive increase in IL-6 production as the less stressed parents in the study as well as altered natural concentration patterns following sleep. An additional study in mice found similar results when subjecting mice to repeated social stress (Avitsur et al., 2001). Many other studies also indicate that hyper-, as well as hypo-, activity of the HPA-axis occurs due to depression and long-term psychological stress in humans (Rohleder et al., 2004; Rohleder et al., 2010) While it should be understood that each different stressor effects the HPA-axis and stress response in a differently, and comparing depression and post-traumatic stress disorder in humans to stressors in cattle are definitely not the same, it still might indicate that this could play a role in the seemingly negative effects of chronic stress on the immune systems of livestock. Additionally, sociological and psychological stressors in livestock will likely never be understood in the same fashion that it is in humans because of the inability to communicate with animals, however research has shown that disrupting social groups and isolating animals can have a measureable impact on stress indicators (Biossy et al., 1997).

Transportation Stress in Cattle

Cortisol, the primarily glucocorticoid produced by most mammals (Carroll and Forsberg, 2007), is often measured as an indicator of response to stress. Administering corticotropin-releasing hormone intravenously has shown to increase circulating cortisol levels on calves that were weaned and trained to lead with a halter, lowering confounding effects of human

interaction with stress (Cooke et al., 2013). This simulates the activation of the HPA-axis in response to stress. Calves handled and bled repeatedly that were not halter trained showed an incremental decreases in cortisol concentrations, indicating an acclimation to handling (Crookshank et al., 1979). Other studies showed no significant difference in cortisol concentrations between transported and non-transported cattle (Arthington et al., 2003). Cortisol does seem to change over time in studies (Crookshank et al., 1979; Buckham Sporer et al., 2007; Buckham Sporer et al., 2008) and is effected by temperament (Burdick et al., 2010; Hulbert et al., 2011) as well as sex (Hulbert et al., 2012). By using staggered groups of contemporaries, Crookshank, et al. (1979), did show that cortisol levels are increased due to transportation, but return to baseline by 2 days post transport. Others accomplished the same result using jugular catheters and stalls (Falkenburg et al., 2013). Regardless, while circulating concentrations of cortisol theoretically can be a good indicator of stress in animals, practically it is difficult to measure accurately due to the stress associated with handling and collecting blood samples from livestock in a real-world setting. Other metabolic indicators of stress and immune response can be measured instead.

Transportation stress might affect the sensitivity of the pituitary gland to ACTH and VP. Knights, et al. (2007), subjected Holstein steers to either 10 hours of transportation stress or used them as non-transported controls. During the 10 hour transportation period, transported calves showed elevated cortisol and ACTH concentrations. Post-transportation, all calves were challenged with CrH and arginine vasopressin (Knights et al., 2007). Non-transported calves exhibited elevated ACTH concentrations at 30 and 60 minutes post hormone injection, while transported calves only had elevated levels of ACTH at the 30 minute time point, which was significantly lower at that time point than the non-transported controls (Knights et al., 2007).

Acute-phase protein concentration can also be effected by transportation stress. Arthington, et al. (2003) found elevated fibrinogen after transportation and differences in fibrinogen and haptoglobin between transported and non-transported newly weaned calves, but these responses were variable. Qui, et al. (2007) shipped 1032 calves across three years, finding that haptoglobin concentrations peak at 24-hr post transportation, with fibrinogen still increasing at 72-hr post transportation. Additional studies have found similar results (Arthington et al., 2008; Buckham Sporer et al., 2008). Lomberg et al., (2008) observed that serum haptoglobin continued to increase through the end of the sampling period at 48 hours after a complex chronic stress event that included transportation, social isolation, and tie-stall housing in mature clinically health Holstein cows.

Allowing cattle to rest on long trips has become a debate topic recently with potential changes to laws that regulate long-haul drivers have been purposed. An experiment that compared cattle hauled 1290 km without rest, 1290 km with 2 rest stops, and non-transported control animals, showed lower plasma haptoglobin concentrations in cattle hauled and allowed to rest twice versus non-rested transport cattle and no difference in ceruloplasmin concentration upon arrival in the feedyard (Cooke et al., 2013). Genetic background and sex also influence this interaction of transportation stress on acute-phase protein concentrations (Qui et al., 2007; Buckham Sporer et al., 2008). Acute-phase protein concentrations may also be an indicator of future performance in the feedyard, having a negative correlation with average daily gain in otherwise healthy calves (Qui et al., 2007).

Several studies have been conducted by Earley et al. (2006; 2011; 2012; 2013) shipping calves from Ireland to Lebanon, Spain, Italy, and elsewhere. Published in 2012, one of these studies transported weaned heifers and bull calves from Ireland to Spain and Italy, respectively.

The journey for the both heifers and bulls took 5 days and included multiple loading events and several rest periods, but trailers were bedded with hay and were equipped with water access, unlike typical domestic transportation methods. Differences were seen by sex, as bulls showed no differences in IFN-γ until d 40, while heifers were different when compared to unshipped controls throughout the shipping events, indicating impaired cellular immunity in the heifers (Earley et al., 2012). Lymphocyte percentage was reduced by half and Neutrophil percentage was more than double unshipped controls in heifers (Earley et al., 2012). A similar study shipped bulls to Lebanon on a 12 day sea journey, and saw significant changes in white blood cell count, lymphocyte percentage, neutrophil percentage, and cortisol for shipped calves versus unshipped controls (Earley et al., 2011). A third study compared the difference in long distance road transport versus just moving bulls to a new housing location (Earley et al., 2013). While they did see differences in lymphocyte and neutrophil percentages immediately after transport, there were no differences in neutrophil percentage, lymphocyte percentage, white blood cell count, or haptoglobin after 1-4 hours of rest (Earley et al., 2013). However haptoglobin and neutrophil percentage were significantly higher and lymphocyte percentage was significantly lower than pre-shipment for both transported and non-transported, new environment bulls (Earley et al., 2013). This may show that the change in environment plays a bigger role in transportation stress than we might have thought. Earley, et al. (2006), also investigated fasting cattle for 8 hours prior to an 8 hour transportation. They found no difference between fasted and transported and non-fasted and transported cattle for neutrophil count or lymphocyte count, but did see a reduction in lymphocytes and an increase in neutrophils in transported animals versus non-transported animals (Earley et al., 2006).

Transportation stress usually creates an increase in neutrophil counts as well as eosinophils and mononuclear cells and a decrease in lymphocytes (Swanson et al., 2001), much like what has been described above. Buckham Sporer, et al. (2007), showed a greater than 3 fold increase in neutrophil counts in bulls approaching 10 hours post transportation, with that returning to baseline by 24 hours post transport. Hulbert, et al. (2012) also demonstrated differences by sex in response for IL-6, IFN-γ, TNF-α, leukocyte number and neutrophil to lymphocyte ratio when challenged with corticotropin-releasing hormone were different by sex. Interestingly, long transportation periods may alter gene expression and potentially reprogram neutrophils to have a longer lifespan and increased proteolytic and tissue sterilizing capabilities (Buckham Sporer et al., 2007). Phillips et al., (1989) did not show a link between genotype and changes in leukocytes, monocytes and neutrophils due to transportation, but Buckham Sporer et al., (2008) did indicate a tendency for breed to effect leukocyte counts at P<0.10.

Separating the stress of weaning from transportation is a normal and preferred added-value practice in the industry. Even calves weaned for short periods (20-21 days) subjected to transportation have been demonstrated to have greater feed intake and weight gain compared to unweaned contemporaries (Meléndez et al., 2021). Arthington et al., (2005) demonstrated that early weaned calves (70-90 days of age) had lower haptoglobin concentrations at day 4 and lower ceruloplasmin concentrations at day 8 after feedyard arrival as compared to contemporaries weaned at a more normal age (300 days of age), while also having greater ADG and more efficient gain in the backgrounding phase (after normal weaned calves were weaned) with negligible differences during finishing and on the rail. Differences in performance are more likely due to compensatory gain than weaning time as the early weaned calves were 48 kg lighter at the time the normal weaned calves were weaned. With acute phase proteins, it would be

difficult to completely understand if the differences were due to the time weaned or to some other function of the early weaned calves developing differently than their normal counterparts. In a subsequent study, Arthington, et. al. (2008) compared early weaned calves, creep fed calves, traditionally preconditioned calves (53 days weaned), and unweaned calves during transportation and finishing in the feedyard. All treatments had superior ADG early in the feedyard, however haptoglobin concentration did not have clear differences between weaning treatments (Arthington et al., 2008).

Microbiological contaminants of Beef

Foodborne illness in the United States is a major concern for all domestic food producers. Scallan et al. (2011) estimated in 2011 that 31 major pathogens found in food cause 9.4 million episodes of foodborne illness, 55,961 hospitalizations, and 1,351 deaths in the United States on an annual basis. When trying to quantify the economic impact of foodborne illness on the U.S., Scharff's (2011) two models estimated the health-related costs at either $51.0 billion (90% CI; $31.2 to $76.1 billion) or $77.7 billion (90% CI; $28.6 to $144.6 billion). Regardless of the model, it is clear that foodborne illness is a major issue in U.S., not only from a public-health standpoint, but also an economic perspective.

While beef is not the sole driver of food related sickness, it is a relevant commodity worthy of consideration. When reviewing data from 1998 through 2008 from the Centers for Disease Control and Prevention (CDC), Painter et al. (2013) reported that beef was responsible for 639,640 illnesses, 3,075 hospitalizations, and 55 deaths annually. This represents 12.2% of annual illnesses, 5.4% of hospitalizations, and 3.8% of deaths in the datasets. In each category, the vast majority of beef related foodborne illness was related to bacterial agents.

Salmonella spp.

According to the CDC, *Salmonella* spp. is responsible for 1.35 million infections, 26,500 hospitalizations, and 420 deaths in the United States, annually (CDC, 2021). Non-typhoidal *Salmonella* is considered to be the most common source of bacterial foodborne illness in the US, with ground beef being the major product of concern in the beef industry (Laufer et al., 2015).

Salmonella is a gram-negative, rod-shaped bacteria that is a member of the family *Enterobacteriaceae* (Popoff, et. al., 2015). This facultative anaerobe has more than 1800 known serovars (Giannella, 1996). In ground beef-related *Salmonella* outbreaks from 1973-2011, 72.7% of cases were attributed to the serotypes Typhimurium, Newport, and Enteritidis (Laufer et al., 2015). Multiple studies would indicate that Typhimurium is the most common serotype isolated from beef cattle, but many others are also associated with cattle (Abouzeed et al., 2000; Sorensen et al., 2002; Fegan et al., 2004;)

Beach et al. (2002) investigated the presence of *Salmonella* in beef cattle. They reported that in feedlot cattle and in adult beef cattle transported to slaughter, *Salmonella* was cultured much more frequently from the hides of cattle post-tranportation than pre-transportation (56% and 52.2% vs. 18% and 19.6%) while rectal swabs for the detection of fecal shedding were less conclusive as feedlot cattle were not different (5% and 3%, pre- and post-transport) and adult slaughter cattle increased after transportation (1% to 20.8%). Additionally, 19% of feedlot cattle carcasses and 54.2% of adult cattle carcasses were found to be contaminated with *Salmonella* when briskets were sampled using sponge swabs during the harvest process. It is unclear if the samples taken as a part of this study were taken prior to any microbial intervention steps or at what step in the slaughter process samples were taken. Additionally, different harvest facilities were used for feedlot cattle and adult cattle. Reasons for carcass differences, therefore, might be

difficult to understand. The increase in *Salmonella* prevalence on hides post-transportation to the harvest facility seen in this study is consistent with results of other studies (Barham et al., 2002).

Dewell et. al (2008) conducted a large study encompassing 40 lots of cattle (approximately 6,720 head) from 18 different feedyards being transported to two different harvest facilities. The objective of their study was to evaluate the effects of feedyard environment, transportation, lairage, and other factors on recovery of *S. enterica* from hides at the time of slaughter. 80% of lots contained at least one positive sample, and in those lots positive samples ranged from 5% to 95% of the swabs collected at the plant. The authors utilized a univariate analysis and then a multivariate analysis to determine what measured variables had a significant impact on post-transportation status of hide contamination. It was concluded that cleanliness of pens at the harvest facility, cleanliness of the trailer, animal behavior during loading, time off feed, transportation distance, and pre-transportation hide contamination had significant influences on hide contamination in the plant. Portions of this study might are in contrast with others papers in the literature. Reicks et. al (2007) observed that trailer cleanliness had no impact on hide contamination with *Salmonella*, however these authors used a total of 50 animals as compared to the very large dataset described above. Regardless, the scale and detail of the Dewell study clearly demonstrated that managing cattle at the end of the feeding period and during the transportation phase to reduce *Salmonella* populations is a complex and all-encompassing task that might not be truly feasible in a production setting.

Detection of *Salmonella* is seasonal, and potentially regional as well. Barkocy-Gallahar et al. (2003) determined that *Salmonella* detection on cattle hides increased from spring (61.4% positive) to summer (91.6%) to fall (97.7%) then declined in the winter (27.7%). Positive swabs from pre-evisceration carcass also peaked in the summer sampling period (24.9%) and fecal

swab positives peaked in the summer (9.1%). Rivera-Betancourt et. al (2003) observed that two plants in two different geographical regions of the U.S. (south and north) had drastic differences in the prevalence of *Salmonella* on the hides of the cattle coming into the plant and on the fences in the holding pens, however they saw no differences in carcass contamination. Additionally, they observed in the northern facility a similar seasonal trend for *Salmonella*, as is mentioned in the previous study, from April through October with *Salmonella* prevalence increasing through the summer and fall then decreasing in October, however there was very little change in prevalence in the southern facility, with October only being slightly lower than the rest of the sample months.

During the harvest process, hides appear to be the primary source of contamination with many studies suggesting that large percentages of cattle enter the processing facility with contaminated hides (Bacon et al., 2002; Barkocy-Gallahar et al., 2003; Koohmaraie, et al, 2012). Compounding that problem is that the midline of the animal appears to have greater contamination than other parts of the hide (Reicks et al., 2007), where the hide must be opened to begin the hide removal process. However, as mentioned previously, several studies show a greatly reduced percentage of positive carcasses prior to microbial interventions as compared to positive hides (Beach, et. al., 2002; Barkocy-Gallaher et al., 2003; Riveria-Betancourt et al., 2003) and virtual no positive carcasses post-microbial intervention (Riveria-Betancourt et al., 2003). Despite that, *Salmonella* spp. has also been detected in beef at the retail level. Zhao et al. (2001) found that 1.9% of 210 beef samples taken from stores in the Washington, D.C. area in 1999-2000 were *Salmonella* positive. This would agree with results from other studies investigating ground beef and other fresh beef samples in the United States (Koohmaraie et al., 2012) as well as aboard (Stevens et al., 2006; Meyer. et. al, 2010; Sallam et al., 2014).

Salmonella contamination of beef products could be the result of cross-contamination by consumers, and in "ready-to-eat" or fully cooked beef products, such as delicatessen-style roast beef, it is almost certainly so (Laufer et al., 2015). However, this doesn't explain the small percentage of positive *Salmonella* samples found in ground beef and in trimmings in plants (Koohmaraie et al., 2012). Increasingly, evidence would also suggest that lymph nodes are a source of contamination in ground beef as they are impossible to treat with traditional microbial interventions in beef processing facilities (Arthur et al., 2008; Koohmarie et al., 2012; Wilkerson et al., 2020), and physical removal of all lymph nodes during processing is impossible.

Escherichia coli O157:H7

Escherichia coli is a gram-negative bacillus that is a normal part of the intestinal flora, however there are many subtypes that can cause intestinal and extraintestinal illness in humans. (Mueller, et. al., 2021). *E. coli* O157:H7, is one of the Shiga toxin-producing subtypes, that can cause a spectrum of illness in humans, but most notably, it is known for causing hemorrhagic colitis, diarrhea, hemolytic-uremic syndrome, and complications associated with these illnesses (Tarr, 1995).

Over the last 40+ years, *Escherichia coli* O157:H7 has become one of the most heavily researched and scrutinized pathogens in fresh beef, and specifically ground beef. Riley et al., (1983) described the investigation of 2 foodborne illness outbreaks in 1982 that resulted in "bloody diarrhea". Their stool cultures did not relieve any previously recognized pathogens, but rather "…a rare *Escherichia coli* serotype, O157:H7…". This outbreak was the first time in the United States that *E. coli* O157:H7 had been identified as the cause of the outbreak (Riley et al., 1983). After a series of additional outbreaks linked to ground beef and *E. coli* O157:H7, USDA-FSIS officially labeled *E. coli* O157:H7 an adulterant in ground beef and initiated a microbial

testing program for raw ground beef in processing plants and retail stores in 1994 (Ebel, et. al., 2003).

As beef cattle are considered the primary source of this pathogen, understanding the prevalence and location of *E. coli* O157:H7 in the live animal is important when trying to understand how to limit its impact on food safety. Fecal shedding of *E. coli* O157:H7 within herds has been shown to be inconsistent, at times, with the rate of animals shedding suddenly changing and herds that had no positive tests at one point spontaneously testing positive at a later date (Besser et al., 1997). This has been shown to range from 0% to 100% shedding in the same group of animals over time (Khaitsa et al., 2003). Smith et al., (2001) conducted a study to evaluate factors that effect the fecal shedding of *E. coli* O157:H7 in fed cattle housed in 29 different feedlot pens at 5 relatively small (3,000-12,000 head capacity) feedlots in the in the Midwest. In this study, prevalence of the pathogen in feces was not different between feedlots, but was different between pens. The condition of the pen (dusty, normal, or muddy) had an effect on the percentage of cattle within the pen shedding *E. coli* O157:H7, as muddy pens were greater than dusty or normal pens. The lack of variation between feedlots suggests that O157:H7 is common among the cattle population (at least in the Midwest region, at that time) and the effect of pen condition highlights the importance of pen management as well as the weather challenges that could affect shedding of pathogens. Studies do support the idea that *E.coli* O157:H7 prevalence is seasonal, with more of the pathogen being cultured in the summer and fall as opposed to winter and spring (Van Donkersgoed et al., 2001; Barkocy-Gallahar et al., 2003; Khang et al., 2009;). All of these factors are important to understand during the live animal production phase, as increased fecal shedding and increase hide contamination can subsequently

have a negative impact on sanitary dressing procedures and cross-contamination on the harvest

floor during hide removal and evisceration (McEnvoy et al., 2003).

Multilevel pathogen intervention to reduce the likelihood of food contamination is

common within the processing facility, but research has also been conducted to evaluate ways to

reduce pathogen load as animals arrive at the plant. Direct-fed microbials have been shown to

reduce the prevalence of *E. coli* O157:H7 in feces and on cattle hides at slaughter while having a

negligible effect on feedyard and carcass performance (Brashears et al., 2002; Peterson, et. al.,

2007). Other feed additives have also been demonstrated to reduce the shedding of *E. coli*

O157:H7 including sodium chlorate (Callaway et al., 2002), and Tasco (Bach et al., 2008).

Vaccination of cattle with Type III proteins secreted by an *E. coli* O157:H7 strain has been

shown to significantly reduce fecal shedding of the pathogen and likely reduce colonization of

the gut by the microorganism (Potter, et. al., 2004), although other data suggests vaccination is

not a clear-cut answer to reducing shedding (Van Donkersgoed et al., 2005; Wileman, et. al.,

2010). The adoption of any of this technology does not seem to be widespread in the commercial

beef industry at this time, likely due to a lack economic incentive to implement them.

Effect of cow-calf and backgrounding management on microbial populations

A systems level approach is logical for controlling and mitigating the potential risks of

foodborne illness in the beef supply chain. This approach must begin prior to arrival of cattle at

the feedyard, in the cow-calf and backgrounding phases. While it is assumed that the majority of

the transmission of these pathogens occurs at the feedyard, some data would show that calves

can already possess these microorganisms before leaving their home ranch. A study conducted in

1997 of 15 cow herds in Kansas, Missouri, Montana, Nebraska, and South Dakota found that 13

of the 15 herds had at least 1 positive fecal sample of *E. coli* O157:H7 with 7.4% of calves

testing positive on average prior to any comingling with foreign livestock (Laegreid et al., 1999). Similar results were found in Canada (Gannon et al., 2002), the state of Washington (Hancock et al., 1994), Alabama (Zhao et al., 2013), and Louisiana (Dunn et al., 2004).

Backgrounding/preconditioning can potentially have an effect on shedding of pathogens. Bach et al., (2004) observed the effects of a short precondition period (13 days) versus unweaned calves on short (3 hour) and long (15 hour) transportation to the feedyard on the shedding of generic *E. coli* as well as *E. coli* O157:H7. *E. coli* O157:H7 was not detected in any of the calves that were weaned until after 21 days in the feedyard, as opposed to unweaned calves, which began to shed as early at 1 day after arrival. Su et al., (2011) evaluated how the diet might impact shedding. This project used temper rolled barley, wheat dried distiller's grain, corn dried distiller's grain, or millrun as different concentrate components to a corn silage-based backgrounding diet for beef heifers. The barley diet displayed greater fecal *E. coli* counts during the backgrounding phase. The authors presumed that this could be due the increased starch content of the barley, which would change the rumen environment in comparison to the other 3 diets. Zhao et al. (2014) cultured *E. coli* O157:H7 from calves weaned on corn silage based diet versus a peanut/soy hull based diet, finding that calves on the corn silage diet had a greater prevalence for the pathogen in fecal samples.

Data in the area of weaning management and it's impact on microbial shedding is fairly limited. *Salmonella* has been extensively researched in swine and dairy cattle, but is an emerging issue in beef cattle. While two papers described above investigate backgrounding diet and its effect on pathogen shedding in beef calves, neither study examines differences in forage types. The single weaning study presented above is promising, but again is a single study and doesn't accurately reflect industry practices for weaning (13 days weaned in the study vs. 60+ day

standard weaning programs in the beef industry). Additionally, little of this work has been conducted in the southeastern region of the U.S., despite the large number of calves produced in the area. This presents a gap in the literature in understanding how to limit pathogen shedding and spread in the U.S. beef cattle production system.

Retained Ownership

As demonstrated throughout the review of the literature above, management by cattlemen during the subsequent segments of the beef production chain can have a great impact in the feedyard and on carcass merit. However, due to the heavy segmentation of the industry, performance information and other valuable data points that are gathered in the feeding phase and at the slaughter facility are not regularly shared back down the chain to the backgrounder or cow-calf producer. Compounding this problem, without some knowledge about the capabilities of their cattle in the feedyard and on the rail, maintaining ownership of cattle through the feeding phase has the potential to be disappointing experience for cattle producers (Marsh and Feuz, 2002). For many producers, the risk associated with feeding cattle is too great, prompting many to market their cattle at weaning or after preconditioning (Fausti et al., 2003; Gillespie et al., 2004; Pope et al., 2011)

However, integrating the backgrounding and feeding/finishing phases of the beef production system into a cow-calf operation can provide benefits that some producers find attractive. In short, this marketing program called "retained ownership" (RO) refers to a feeder calf management strategy in which beef producers maintain ownership of cattle throughout the finishing period, whether that scenario is an on-farm application or shipping to a custom feedyard and compensating outside parties to finish the cattle (Lawrence, 2005). By doing this, producers can take advantage of the profit potential in all phases of live cattle production, not

just the cow-calf sector. Several studies indicate that RO is a profitable marketing strategy in most years (Wagner et al., 1991; Fausti et al., 2003; Tang et al., 2017)

<u>Conclusion</u>

Regardless of the nomenclature or the exact production system, the portion of the beef industry that takes newly-weaned calves, increases their size and maturity, and prepares them for entry in the feedyard is incredibly important, both to the beef industry over all, but also to the animal. From a nutritional standpoint, this segment of the industry provides great opportunity to use available forage resources across the U.S. and co-product concentrate feed ingredients to economically and efficiently add weight to cattle. While the literature in this area is fairly mature in terms of the understanding of supplementation on growth performance in growing beef cattle, using new technology for conserving forages (baleage) and the use of warm-season grazing systems for fall-born southeastern calves are both surprisingly under-studied. Further, there is an apparent lack of understanding the effects of backgrounding, and specifically diet during the backgrounding period, in this summer weaning system on transportation stress, feedyard performance, carcass characteristics, and pathogen shedding of the major pathogens of concern in the beef industry.

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Chapter 2: Feeder Calf Retained Ownership Educational Program:

Alabama Pasture to Rail

Introduction

Modern beef industry in the United States is heavily segmented. In general, the live

production of beef cattle is broken into three major segments: the cow-calf sector, the

stocker/backgrounder sector, and the cattle feeding/finishing industry (Field et al., 2016). Each of

these sectors plays a vital role in the industry. The cow-calf sector is the predominant production

system in the southeastern U.S., where producers calve out mature cows and sell calves at

weaning (Ball et al., 2015). Differences in management strategies used to prepare these calves

for the transition into the feedyard affect performance during the feeding phase as well as on

carcass characteristics after harvest (Choat et al., 2003; Hersom et al., 2004; Lancaster et al.,

2014; Cox-O'Neill et al., 2017). However, due to the segmentation of industry, cattle producers

rarely receive feedback on the performance of their calves after they are sold to a stocker

operator or feeding operation. Compounding this problem, without some knowledge about the

capabilities of their cattle in the feedyard and performance on the rail, maintaining ownership of

cattle through the feeding phase has the potential to be a disappointing experience for cattle

producers (Marsh and Feuz, 2002). For many producers, the risk associated with feeding cattle is

too great, prompting many to market their cattle at weaning or after preconditioning (Fausti et

al., 2003; Gillespie et al., 2004; Pope et al., 2011)

However, integrating the backgrounding and feeding/finishing phases of the beef

production system into a cow-calf operation can provide benefits that some producers find

attractive. This marketing program called "retained ownership" (RO) refers to a feeder calf management strategy in which beef producers maintain ownership of cattle throughout the finishing period, whether that scenario is an on-farm application or shipping to a custom feedyard and compensating outside parties to finish the cattle (Lawrence, 2005). By doing this, producers can take advantage of the profit potential in all phases of live cattle production, not just the cow-calf sector. Several studies indicate that RO is a profitable marketing strategy in most years (Wagner et al., 1991; Fausti et al., 2003; Tang et al., 2017). Retained ownership can be a viable and rewarding feeder calf management strategy for cow-calf producers across the country, and many are already taking advantage of these opportunities. There are several variations of programs that can fit more specific marketing needs of individual producers. Producers are encouraged to evaluate their individual situation before joining a retained ownership program and consider the benefits as well as risks.

In the 1980's, Extension professionals with the Alabama Cooperative Extension System developed a "farmer-feeder" carcass contest called the Alabama Pasture to Rail Program (P2R). At that time, cattle were finished on producer farms and harvested at a central, small processing facility in Alabama. As the cattle industry evolved and the small processing facilities closed in the Southeast, P2R evolved into a program focused on RO. Feeder cattle from across Alabama were consigned and shipped to commercial feedyards in the southern Plains where they were fed until they were harvested at large processing facilities. The program was discontinued in 2011 with as producer interest waned and changes occured in staffing in Extension. In 2016, the program was revived and loads began being shipped again in October of that year. Today the objective of the Alabama Pasture to Rail Program (P2R) is to provide Alabama cattle producers

of all sizes the opportunity to participate in RO and gather performance, health, and carcass data that would be otherwise unattainable.

Methods

The P2R process begins with producers nominating their cattle to the program coordinator. Producers must have minimum of 3 head that have been weaned for a minimum of 60 days, vaccinated twice for IBR, BVD, BRSV, and PI$_3$ with at least one dose being a modified-live virus, vaccinated twice with a 7 or 8-way blackleg vaccine, vaccinated once for *Mannheimia haemolytica* and *Pasteurella multocida*, dewormed within 60 days of delivery, dehorned, and bulls calves must be castrated and healed. Producers are encouraged to re-vaccinate calves if the second dose of vaccine had been given more than 60 days before shipment. Each calf nominated requires a $75.00 consignment fee payable to the Alabama Beef Cattle Improvement Association which is utilized to offset programmatic operations including animal identification, transportation to feedyard, and data collection and analysis. Additional expenses such as feed, medicine, feedyard processing, yardage, and carcass data collection costs are carried by the feedyard until the calves were harvested. At that time, costs are removed from the proceeds received for the sale of the cattle at harvest. As cattle are housed in 30 to 80 head pens without out the ability to collect individual feed intake, feed cost per head is estimated. This is estimated by dividing the total pen feed cost by the total pen weight gain, creating a pen average feed cost of gain. This is multiplied by the individual animal gain to assign feed cost to each animal. For animals that lost weight, they are assigned feed cost as if they had gained 0.91 kg/day to attempt to estimate their feed intake during that time.

Each load is organized 2 to 4 weeks prior to shipment, and at that time a centrally located facility is selected for the producers participating in the shipment. To facilitate the shipment, P2R

only initiated shipments when a minimum of 46,000 estimated pounds of cattle are consigned. One day prior to shipping, all cattle are required to arrive at the shipping facility where they are weighed, visually evaluated to assign feeder calf grades (i.e. frame size and muscle scores), and ear tagged for identification with both radio frequency identification (RFID) tags and visual tags. Using the feeder calf grades and weight, values are estimated for each individual animal based on local livestock market reports for the week of shipping. Differences in price based on sex are taken into account, but breed-type and hide color are not. The following day after initial processing in Alabama, cattle are loaded onto commercial cattle trailers and transported to Hy-Plains Feedyard in Montezuma, Kansas.

After a minimum 24 hours rest upon arrival at the feed yard, calves are processed and sorted into harvest groups. When a single load of cattle is shipped, the load is divided into no more than two harvest groups. When multiple loads are shipped within a week, those loads are commingled and sorted into as many as 3 harvest groups. Harvest dates are projected at processing utilizing classification and sorting software used by Hy-Plains Feedyard, LLC. which accounts for weight and frame size. Actual harvest dates are determined by feedyard staff as the projected date approaches. Using information gathered at feedyard entry, estimated values assigned to calves, and estimated feed cost for the finishing phase, P2R management works with feedyard staff to estimate breakeven projections for each load at this time. When projected profit/cwt reach $8-10/cwt, risk management options are utilized to protect the investment of consigners. This comes either in the form of forward contracting cattle to specific processors or hedging on the futures market.

Calves are sold to one of the major harvest facilities in the region surrounding Hy-Plains Feedyard. All animals are sold on a carcass merit grid, where premiums and discounts are

assessed for USDA yield (YG) and quality grades (QG). After harvest, carcasses are evaluated

and assigned a ribeye area (REA), backfat thickness (BF), hot carcass weight (HCW), marbling

score (MARB), USDA quality grade, and USDA yield grade at the harvest facility. To reduce

stress prior to harvest, live weights are not collected on individual animals. Live weight is

estimated using the individual HCW and the carcass yield percentage of the harvest group. As

such, average daily gains (ADG) are also an estimate, using this estimated live weight.

Consignors receive full growth, carcass, health, and financial data and reports for each individual

animal 7 to 21 days after the final animals in the group were harvested.

In total, 2188 calves were shipped from Alabama from October 2016 through March

2020. These calves were from 72 different farms from across Alabama and 1 farm from southern

Tennessee. All calves were harvested by October 2020. Actual data collected on each animal

included sex, hide color, pre-transportation weight (AL WT), estimated value prior to

transportation (AL VAL), weight at initial processing in the feedyard, number of treatments for

disease during the finishing phase, HCW, REA, MARB, BF, calculated yield grade (yield grade

prior to rounding; CYG), YG, QG, carcass value per head (CAR VAL), carcass value per

kilogram, any carcass defects, and all costs other than feed cost. Cattle shipped from October

2016 through January 2017 are considered the 2017 year. Cattle shipped from September 2017

through June 2018 are considered the 2018 year. Cattle shipped from September 2018 through

February 2019 are considered the 2019 year. Cattle shipped from May 2019 through March 2020

are considered the 2020 year.

Data Analysis

Individual animal was used as the experimental unit in this observational analysis.

Individual animal data used for overall means of measurements compared by year, by sex, and

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by number of times treated were analyzed using GLIMMIX feature in SAS 9.4 (SAS Institute, Inc., Cary, NC). Continuous variables were subjected to analysis of variance using the least squared means syntax for Gaussian distributions with an R-side covariance structure and binomial data was analyzed similarly using the binominal distribution function with an R-side covariance structure. Least square means were separated using the PDIFF function of SAS. Stepwise regression of the effects of various performance, health, and economic measures on profit, then carcass value and hot carcass weight was conducted using the REG feature in SAS 9.4 (SAS Institute, Inc., Cary, NC). Further, Pearson Correlation Coefficients between profit, carcass value, hot carcass weight, and other performance and carcass measurements was conducted using the CORR feature of SAS 9.4 (SAS Institute, Inc., Cary, NC). The significance level was set at $P \leq 0.05$ for all analysis.

Results and Discussion

Results from 2016 to 2020 P2R have provided an insight into the performance characteristics and carcass merit of Alabama feeder cattle. Performance metrics by year are reported in Table 1. Cattle from the 2017 year had the lightest average weight prior to transportation (AL WT), average estimated live weight at slaughter (FINAL WT), hot carcass weight (HCW), average daily gain (ADG), and spent the greatest number of days on feed (DOF). This likely is influenced heavily by one farm that consigned 36.5% of cattle that year (76 hd of 208 hd total), which had lighter than average weights and slower growth possibly because of unique sire breeds used. Cattle harvested as part of the 2020 year were faced with increased time on feed, due to reducing processing capacity and slow response from local packers to purchase cattle after the fire at the Tyson facility in Holcomb, KS in August 2019 and throughout the COVID-19 crisis in early 2020. In early May 2020, national cattle slaughter numbers were

reduced by 35% compared to 2019 (Martinez et al., 2021). This caused those cattle to have the same FINAL WT as the cattle in 2018, which is the greatest of the 4 years, despite having an AL WT that was 27 kg lighter than 2018 cattle.

Performance metrics by sex are reported in Table 2. Steers had greater AL WT, FINAL WT, HCW, and ADG as compared to the heifer. Because of the nature of the program, where cattle were not penned separately by sex, there was no difference between steers and heifers in the number of days in the feedyard prior to slaughter. These results mirror those from Tang et al. (2017) observing cattle from 2005 to 2015 in a similar program feeding cattle from Tennessee in Iowa. These authors found that steers had greater initial body weights, final body weights, HCW, and ADG when compared to the heifers in the program, however carcass data was not reported (Tang et al., 2017). While the weights of the cattle were very similar at the beginning of the feeding period in both programs, final weights were significantly different. Steers in the Tang et al. (2017) article were 38 kg lighter that the steers in this program and the heifers were 68 kg lighter. This is likely due to the fact that the cattle fed in the Tennessee program were fed on average 25 days less than the cattle in P2R. This could likely be attributed to changes in the cattle feeding industry surrounding the droughts in 2011 and 2012. Nationally, drought forced the liquidation of more than 2 million cows by early 2014, reducing the numbers of calves in feedyards in the subsequent years (Countryman et al., 2016). This incentivized feedyards to feed cattle longer to meet beef demands from the packing industry. However, finished cattle weights have been on the rise since at least the early 1990's, allowing the industry to have relatively stable beef production despite a shrinking national cowherd (Maples et al., 2019). Data from the 1970s through the early 1990s from other retained ownership programs would support this increase in finish weights over time (Simms et al., 1991; Wagner et al., 1992; Grooms, 1993).

Carcass traits across years (Table 3) indicated that in the 2020 year, feeder cattle expressed the greatest HCW, ribeye area (REA), backfat thickness (BF), percentage of carcasses that graded USDA yield grade 1-3 (%YG1-3), marbling score (MARB), and percentage of carcasses that graded USDA quality grade Choice or Prime (%CH/PR), although HCW, BF, and MARB were not different than 2018 and %YG1-3 and %CH/PR were not different than 2017 or 2018. As described above, cattle in 2020 required additional time on feed due to market disruptions, which could likely be the cause of the increased REA, BF, and MARB. In contrast, 2019 had drastically reduced REA, %YG1-3, and %CH/PR and increased calculated yield grade. Interestingly, 79.5% (485 hd of 610 total) of cattle fed in 2019 were consigned by producers that consigned cattle in at least one other year, indicating that genetics were largely the same across years and that the differences were likely due to some other factor, such as weather in southwest Kansas.

Carcass characteristics differed between steers and heifers (Table 4). Steers had heavier carcasses, larger REA, and a greater %YG1-3. Heifers, by comparison, had fatter carcasses with greater BF and increased CYG, but in-turn had greater MARB and 12.2% more USDA Choice and Prime carcasses. Other studies have shown similar differences in performance and carcass quality by sex (Busby et al., 2004).

Health in the feedyard is a key component to success as it negatively effects performance and profitability (Irsik et al., 2006). The number of times an animal is treated for respiratory disease can be used as a metric for sickness in calves, and can have an effect on performance (Table 5). The majority (88.1%) of calves in P2R were never treated for disease. Cattle that were never treated had the greatest ADG, HCW, BF, and MARB with the lowest %YG1-3 and number of cattle that died or were sold as chronically sick animals prior to slaughter (LOSS%).

Every time animals were treated, LOSS% increased. Ribeye area was not affected by the number of times an animal was treated. Additionally, %CH/PR was not different between 0 and 1 treatments, but decreased at 2 treatments. Busby et al. (2004), found similar results in terms of ADG, MARB, and QG when analyzing data from more than 6,600 calves fed in 2002-03. Additional study results agree with the impact of treatment of performance and carcass traits observed in the present data (Gardner et al., 1998; Roeber et al., 2001; Gadberry and Troxel, 2005; Seeger et al., 2008; Schneider et al., 2009). Profitability was greatly impacted by health. Profit calculations include the loss associated with deaths and cattle sold prior to marketing of their pen. Cattle that were not treated for disease averaged $110.79/hd profit. With a single treatment, profit per head drops to a $60.25/hd loss. Losses continue to grow at 2 and 3 treatments per head. This reduction in profitability due to morbidity agrees other studies (Gardner et al., 1998; Gadberry and Troxel, 2005; Irsik et al., 2006). The small number of animals treated 3 and 4 times reduced the ability to detect what differences might occur consistently in those groups.

From an economic standpoint, there can be significant differences from year to year in per head value (Table 6). The value of calves in Alabama on a per head basis (AL VAL) was greatest in 2018 and 2019, followed by 2020 then 2017 ($P < 0.0001$). Carcass value of calves on a per head basis (CAR VAL) was greatest in 2018 and 2020, followed by 2019 then 2017 ($P < 0.0001$). However, this value takes into account the price protection strategy put in place by P2R management and feedyard staff, and as such. Cattle from the 2020 year are a great example, as the price protection strategy that was put in place using hedges and forward contracts insulated P2R calves from the market pressure of the Tyson fire and COVID-19. At times in 2020, P2R calves were receiving prices up to 40% greater than the limited cash market for unprotected

calves on the same day. This insulated P2R from decisions that other cattle feeders were having

to make: feed cattle longer and hope for better prices or sell into a down market (Martinez et al.,

2021). Instead, feedyard staff were able to be aggressive trying to market cattle whenever

possible. Inversely, this conservative strategy limited upside on CAR VAL for the 2017 cattle.

Regardless, 3 of the 4 years analyzed in this dataset showed average per head profits of $89.95 or

greater, with the other year being largely a breakeven based on AL VAL ($2.18/hd profit). This

agrees with other summaries and articles that RO can be a profitable marketing tool in most

years (Wagner et al., 1991; Fausti et al., 2003; Tang et al., 2017). Tang et al. (2017), specifically,

demonstrated that RO was profitable 8 of 11 years from 2005-2015 with similar cattle of

southeastern origin.

The cost to add weight to cattle is also important when considering profitability (Table

6). Feed cost of gain (FCOG) is the total feed cost accumulated to feed each animal to harvest

weight divided by the total weight gain of the animal in kilograms. Total cost of gain (TCOG) is

the total cost including feed, medicine, processing costs, and all other costs accumulated while

feeding each animal to harvest weight divided by the total weight gain of the animal in

kilograms. Feed cost/kg, feed efficiency, animal performance, and the variation in other costs

can effect each of these numbers each year.

A stepwise regression was conducted to determine what factors are important in

influencing profitability in the feeding phase and what factors a producer can focus on to

improve their opportunities to be profitably in most years. In the initial regression, several

metrics were analyzed to estimate their impact directly on profit including HCW, REA, BF, YG,

QG, MARB, AL VAL, CAR VAL, carcass value per kg (CAR VAL CWT), carcass value

premium/discount, AL WT, total feedyard cost, ADG, DOF, farm of origin, individual load,

shipment month, year, number of times treated for disease, and sex. CAR VAL, AL VAL, and

TOTAL COST were all significant and had a sum partial r^2 of 0.99. This is logical as the

equation for profit is:

Total Carcass Value – All Costs of Feeding – Value of Calf at Delivery = Profit

Interestingly, CAR AL had the greatest impact on profitability with a partial r^2, which is

greater than both AL VAL and TOTAL COST combined (partial r^2 of 0.24 and 0.21,

respectively). No other variable had a partial r^2 greater than 0.01, and are not discussed. This was

further confirmed with Pearson Correlations Coefficients calculated between these terms. The

correlation between Profit and each of these variables (CAR VAL, AL VAL, and TOTAL

COST) was significant ($P < 0.0001$), however they were each very different. AL VAL had a

weak negative correlation with Profit (coefficient = -0.12). TOTAL COST was moderately

correlated with Profit (coefficient = 0.39). CAR VAL was strongly correlated with Profit

(coefficient = 0.88), further confirming that in this dataset CAR VAL is a significant driver of

profitability in feedyard cattle.

Carcass value is not a trait that a producer can directly manage for or use genetic

selection to improve. It is important to understand the traits in these animals that influence CAR

VAL to further inform producers on how to improve profitability. With that in mind, a second

stepwise regression was conducted to evaluate what variables may explain variation in CAR

VAL. All of the variables described in the first regression were used, excluding CAR VAL, AL

VAL, and TOTAL COST. The results of this second regression are shown in Table 8. HCW

explained the greatest amount of variability in CAR VAL with a partial r^2 of 0.70, followed by

CAR VAL CWT and YEAR (partial r^2 0.11 and 0.03, respectively). No other variable had a

partial r^2 greater than 0.01, and are not discussed. Pearson Correlation Coefficients were

examined to confirm this impact and better understand effects on CAR VAL. HCW was strongly

correlated with CAR VAL (coefficient = 0.84), as was CAR VAL CWT (coefficient = 0.74).

This is expected as CAR VAL is calculated by multiplying HCW by CAR VAL CWT to arrive

at CAR VAL, however it is interesting that variation in HCW explains variation in CAR VAL to

a much greater extent than CAR VAL CWT. This could likely be due to the relatively short

nature of the project and relatively low variability in price year to year. With more data over

time, potentially CAR VAL CWT might be of more importance.

Gadberry and Troxel (2006) conducted a similar stepwise regression on the data gathered

from 2,076 steers fed through the Arkansas Steer Feedout program from 1996 to 2005. The

authors analyzed how arrival BW, Final BW, DOF, HCW, QG, YG, dressing percentage,

medicine cost, FCOG, ADG, BF, and USDA muscle score explained variation in return above

feedlot expenses (Gadberry and Troxel, 2006). In 8 of the 9 analyzed years, HCW was the 1 step

in the regression with the greatest partial r^2 in the analysis (Gadberry and Troxel, 2006).

Interestingly, in 7 of the 9 years QG ranked as either the 2nd or 3rd step in the regression

(Gadberry and Troxel, 2006). It is important to note that the cattle in this program had a much

lower percentage of cattle that graded USDA Choice or Prime compared to P2R data. With

76.1% of all cattle harvested in P2R during these 4 years, the variation in QG is much lower than

what was seen by others (Gadberry and Troxel, 2005;). Since Savell and Cross (1994) called for

value-based marketing to become commonplace in the beef industry, cattle producers and

feeders have answered. National Beef Quality Audit data would indicate that the percentage of

cattle grading USDA Choice and Prime is on the rise (Boykin et al., 2017). It is possible that in

the future cattle that don't reach USDA Choice will be penalized heavily, but overall USDA

Quality Grade could become simply a pass/fail variable for profitability instead of a scaling factor at each of the 4 USDA Quality Grades for fed beef.

Much like CAR VAL, HCW itself is not a trait that producers can actively manage during the cow-calf phase or in the backgrounding period. Further clarification was desired to determine what traits a cattle producer should select or manage for to achieve in order to ensure heavier carcass weights, which in-turn create greater carcass value, then hopefully greater profits. Based on this objective, a third stepwise regression was conducted (Table 9). This regression used the same variables listed in the first regression, excluding the six terms listed in Table 7 and Table 8. With a combined partial r^2 of 0.95, ADG, AL WT, and DOF (individual partial r^2 of 0.62, 0.19, and 0.14, respectively) explain the majority of the variation in HCW. No other variable had a partial r^2 greater than 0.01, and are not discussed. As evaluated previously, Pearson Correlation Coefficients were examined to confirm these effects on HCW. Both ADG and AL WT had strong, positive correlations with HCW in this data set (coefficients = 0.79 and 0.57, respectively). DOF was negatively correlated with HCW (coefficient = -0.21). While this might seem counterintuitive, it is important to remember that the larger cattle are on arrival at the feedyard the fewer number of days they are likely to spend on feed before being ready for harvest. As such, DOF was negatively correlated and AL WT was positively correlated with HCW. In an environment where DOF varied, but AL WT remained constant, a greater number of DOF would likely increase HCW. In this system, the inverse is more likely to occur due to the relationship between DOF and AL WT.

Regardless, producers interested in increasing HCWs in their cattle would benefit from producing cattle that had greater growth potential (increasing ADG in the feedyard) and send those cattle at greater weights. Increased weights could come from two sources: larger calves at

the end of a short backgrounding period due to increased genetic potential and nutritional

management or maintaining calves through a longer backgrounding period to create a more

traditional "yearling" steer or heifer to go into the feedyard. Lancaster et al. (2014) clearly

demonstrated in their meta-analysis that systems generating yearlings will have increased ADG,

but typically decreased feed efficiency during the feeding phase. Other studies looking

evaluating various backgrounding systems for calves indicate that increased performance during

preconditioning and greater weights at feedyard entry increase performance and HCW (Choat et

al., 2003; Hersom et al., 2004; Cox-O'Neill et al., 2017).

Conclusions

Analysis of P2R results demonstrate the importance of collecting growth, carcass,

and financial data for producers. Analyzing this data overall demonstrates that Alabama feeder

cattle meeting industry standards for performance and carcass quality, but also serves as an

educational program illustrating keys to success for producers interested in RO. This data clearly

demonstrates that calf health is the key underlying consideration when considering RO. Even

cattle that are only treated a single time are significantly more likely to die and have reduced

performance. When managing an operation with end goal of RO, cattlemen should strive to

produce calves that have increased growth potential, are of greater size at feedyard entry either

through larger breed-type and nutritional management or yearling production system, and have

the potential to at least meet minimum industry standards for carcass quality.

Collecting such data ultimately allows producers to make the decisions needed in

breeding programs and management practices within their individual beef production systems to

improve in these areas and increase their opportunities for profitability. Without P2R, a smaller

cow-calf producer would not have the ability to capture RO data due to limited options of

placing smaller numbers of cattle into a feedyard setting. Thus, smaller producers would typically be limited to making management decisions based only on phenotypic traits expressed up to or shortly after weaning. As a result, the overall impact of P2R is to quantify beef production information for Alabama beef producers in an effort to guide management among producers that enhance production and sustainability of cattle in the beef supply chain.

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TABLE 1.

GROWTH PERFORMANCE OF BEEF CATTLE ENROLLED IN THE ALABAMA PASTURE TO RAIL RETAINED OWNERSHIP PROGRAM BY YEAR

	2017	*2018*	*2019*	*2020*	*P-value*	*SEM[6]*
AL WT[1]	308[c]	349[a]	327[b]	322[b]	<0.0001	2.6
FINAL WT[2]	567[c]	607[a]	584[b]	606[a]	<0.0001	3.6
HCW[3]	366[c]	392[a]	375[b]	394[a]	<0.0001	2.1
ADG[4]	1.44[c]	1.65[a]	1.50[b]	1.54[b]	<0.0001	0.02
DOF[5]	186[a]	160[c]	170[b]	188[a]	<0.0001	1.2

[1]AL WT, Individual weights of animals in Alabama prior to transportation to the feedyard, in kilograms.
[2]FINAL WT, Finished weight of animals at harvest in kilograms, estimated by dividing actual hot carcass weights by pen dressing percentage.
[3]HCW, Hot Carcass Weight in kilograms
[4]ADG, Average Daily Gain through the feeding period in kilograms per day.
[5]DOF, Number of Days cattle were On Feed.
[6]SEM, Standard Error of the Mean.
[a,b,c]Mean values within a row with different superscripts are significantly different (P < 0.05).

TABLE 2.

GROWTH PERFORMANCE OF BEEF CATTLE ENROLLED IN THE ALABAMA PASTURE TO RAIL RETAINED OWNERSHIP PROGRAM BY SEX

	Steers	*Heifers*	*P-value*	*SEM[6]*
AL WT[1]	333[a]	324[b]	0.0003	1.8
FINAL WT[2]	605[a]	581[b]	<0.0001	2.4
HCW[3]	391[a]	375[b]	<0.0001	1.4
ADG[4]	1.58[a]	1.50[b]	<0.0001	0.01
DOF[5]	174	175	0.18	0.9

[1]AL WT, Individual weights of animals in Alabama prior to transportation to the feedyard, in kilograms.
[2]FINAL WT, Finished weight of animals at harvest in kilograms, estimated by dividing actual hot carcass weights by pen dressing percentage.
[3]HCW, Hot Carcass Weight in kilograms
[4]ADG, Average Daily Gain through the feeding period in kilograms per day.
[5]DOF, Number of Days cattle were On Feed.
[6]SEM, Standard Error of the Mean.
[a,b,c]Mean values within a row with different superscripts are significantly different (P < 0.05).

TABLE 3.

**CARCASS CHARACTERISTICS OF BEEF CATTLE ENROLLED IN THE
ALABAMA PASTURE TO RAIL RETAINED OWNERSHIP PROGRAM BY YEAR**

	2017	*2018*	*2019*	*2020*	*P-value*	*SEM[8]*
HCW[1]	366[c]	392[a]	375[b]	394[a]	<0.0001	2.1
REA[2]	91.4[c]	96.3[b]	88.9[d]	98.5[a]	<0.0001	0.53
BF[3]	1.43[b]	1.56[a]	1.40[b]	1.58[a]	<0.0001	0.024
CYG[4]	2.78[b]	2.88[b]	3.10[a]	2.80[b]	<0.0001	0.041
% YG1-3[5]	94.5%[a]	90.5%[a]	85.0%[b]	92.7%[a]	<0.0001	1.41%
MARB[6]	456[b]	491[a]	445[b]	490[a]	<0.0001	4.6
% CH/PR[7]	81.4%[a]	81.8%[a]	59.4%[b]	83.4%[a]	<0.0001	1.97%

[1]*HCW, Hot Carcass Weight in kilograms*
[2]*REA, Ribeye Area in square centimeters*
[3]*BF, Backfat thickness in centimeters*
[4]*CYG, Calculated USDA Yield Grade, or the unrounded USDA Yield Grade calculation*
[5]*% YG 1-3, Percentage of carcasses that were graded USDA Yield Grade 1, 2, or 3*
[6]*MARB, Marbling Score, 300-399 = Slight Degree of Marbling, 400-499 = Small, 500-599= Modest*
[7]*% CH/PR, Percentage of carcasses that were graded Choice or Prime*
[8]*SEM, Standard Error of the Mean.*
[a,b,c]*Mean values within a row with different superscripts are significantly different (P < 0.05).*

TABLE 4.

GROWTH PERFORMANCE OF BEEF CATTLE ENROLLED IN THE ALABAMA PASTURE TO RAIL RETAINED OWNERSHIP PROGRAM BY SEX

	Steers	*Heifers*	*P-value*	*SEM[8]*
HCW[1]	391[a]	375[b]	<0.0001	1.4
REA[2]	95.5[a]	92.6[b]	<0.0001	0.38
BF[3]	1.43[b]	1.65[a]	<0.0001	0.016
CYG[4]	2.83[b]	3.05[a]	<0.0001	0.028
% YG1-3[5]	93.0%[a]	84.8%[b]	<0.0001	0.95%
MARB[6]	458[b]	505[a]	<0.0001	3.1
% CH/PR[7]	71.8%[b]	84.0%[a]	<0.0001	1.35%

[1]HCW, Hot Carcass Weight in kilograms
[2]REA, Ribeye Area in square centimeters
[3]BF, Backfat thickness in centimeters
[4]CYG, Calculated USDA Yield Grade, or the unrounded USDA Yield Grade calculation
[5]% YG 1-3, Percentage of carcasses that were graded USDA Yield Grade 1, 2, or 3
[6]MARB, Marbling Score, 300-399 = Slight Degree of Marbling, 400-499 = Small, 500-599= Modest
[7]% CH/PR, Percentage of carcasses that were graded Choice or Prime
[8]SEM, Standard Error of the Mean.
[a,b,c]Mean values within a row with different superscripts are significantly different (P < 0.05).

TABLE 5.

INFLUENCE OF MORBIDITY ON PERFORMANCE OF BEEF CATTLE ENROLLED IN THE ALABAMA PASTURE TO RAIL RETAINED OWNERSHIP PROGRAM

| | Number of treatments for disease | | | | | | |
	0	1	2	3	4	P-value	SEM[12]
N[1]	1928	183	52	24	1		
N%[2]	88.1%	8.4%	2.4%	1.1%	0.0%		
ADG[3]	1.59^a	1.41^b	1.08^c	0.45^d	0.45^{cd}	<0.0001	0.039
HCW[4]	388^a	369^b	358^b	318^c	241^c	<0.0001	15.53
REA[5]	94.5	94.5	93.5	91.4	78.6	0.64	1.95
BF[6]	1.53^a	1.32^b	1.22^b	0.91^b	1.12^b	<0.0001	0.017
% YG1-3[7]	89.3%^{b}	97.0%^{a}	97.6%^{ab}	100%^{ab}	100%^{ab}	0.0081	9.75%
MARB[8]	478^a	450^b	438^b	398^b	603^{ab}	0.0001	32.7
% CH/PR[9]	77.0%^{a}	72.7%^{a}	54.8%^{b}	42.9%^{ab}	100%^{ab}	0.0020	13.90%
LOSS%[10]	0.8%^{d}	9.3%^{c}	19.2%^{b}	70.8%^{a}	0%^{bcd}	<0.0001	4.06%
PROFIT[11]	$110.79^a	-$60.25^b	-$241.95^c	-$871.81^d	-$154.56^{abd}	<0.0001	$27.44

[1]N, total number of animals per treatment group

[2]N%, percentage of total animal per treatment group.

[3]ADG, Average Daily Gain through the feeding period in kilograms per day.

[4]HCW, Hot Carcass Weight in kilograms

[5]REA, Ribeye Area in square centimeters

[6]BF, Backfat thickness in centimeters

[7]% YG 1-3, Percentage of carcasses that were graded USDA Yield Grade 1, 2, or 3

[8]MARB, Marbling Score, 300-399 = Slight Degree of Marbling, 400-499 = Small, 500-599= Modest

[9]% CH/PR, Percentage of carcasses that were graded Choice or Prime

[10]LOSS%, percentage of cattle within treatment group that died or were sold as chronically sick animals prior to the slaughter of their pen.

[11]PROFIT, Total profit on a per head basis above the original Alabama value

[12]SEM, Standard Error of the Mean.

[a,b,c]Mean values within a row with different superscripts are significantly different (P < 0.05).

TABLE 6.

ECONOMIC DATA OF BEEF CATTLE ENROLLED IN THE ALABAMA PASTURE TO RAIL RETAINED OWNERSHIP PROGRAM BY YEAR

	2017	*2018*	*2019*	*2020*	*P-value*	*SEM[6]*
AL VAL[1]	$715.33[c]	$934.42[a]	$919.70[a]	$837.36[b]	<0.0001	$5.40
CAR VAL[2]	$1399.66[c]	$1572.07[a]	$1518.81[b]	$1600.91[a]	<0.0001	$15.88
FCOG[3]	$1.57[bc]	$1.54[c]	$1.68[b]	$1.78[a]	<0.0001	$0.037
TCOG[4]	$1.97[b]	$1.75[c]	$1.95[b]	$2.18[a]	<0.0001	$0.062
PROFIT[5]	$138.20[a]	$89.95[b]	$2.18[c]	$112.10[ab]	<0.0001	$12.75

[1]AL VAL, Alabama Value, the average per head value of calves at the time of shipping from Alabama
[2]CAR VAL, Carcass Value, the average per head value of carcasses after all premiums, discounts, and risk management.
[3]FCOG, Feed Cost of Gain or the feed cost incurred in the feedyard divided by kilograms of gain; reported as dollars per kilogram of gain
[4]TCOG, Total Cost of Gain or the total cost incurred in the feedyard divided by kilograms of gain; reported as dollars per kilogram of gain
[5]PROFIT, Total profit on a per head basis above the original Alabama value
[6]SEM, Standard Error of the Mean.
[a,b,c]Mean values within a row with different superscripts are significantly different ($P < 0.05$).

TABLE 7.

MULTIPLE REGRESSION OF GROWTH, CARCASS, HEALTH, AND ECONOMIC METRICS ON THE DEPENDENT VARIABLE PROFIT OF BEEF CATTLE ENROLLED IN THE ALABAMA PASTURE TO RAIL RETAINED OWNERSHIP PROGRAM[1]

INDEPENDENT VARIABLE	Partial r^2	P-value
CAR VAL[2]	0.54	<0.0001
AL VAL[3]	0.24	<0.0001
TOTAL COST[4]	0.21	<0.0001

[1]Stepwise regression included 20 independent variables regarding growth, carcass traits, health, and economic data. Only significant variables (P<0.05) with a partial r^2 greater than 0.02 are listed.
[2]AL VAL, Alabama Value, the average per head value of calves at the time of shipping from Alabama
[3]CAR VAL, Carcass Value, the average per head value of carcasses after all premiums, discounts, and risk management.
[4]TOTAL COST, Total Feedyard Costs per head

TABLE 8.

MULTIPLE REGRESSION OF GROWTH, CARCASS, HEALTH, AND ECONOMIC METRICS ON THE DEPENDENT VARIABLE CARCASS VALUE OF BEEF CATTLE ENROLLED IN THE ALABAMA PASTURE TO RAIL RETAINED OWNERSHIP PROGRAM[1]

INDEPENDENT VARIABLE	Partial r^2	P-value
HCW[2]	0.70	<0.0001
CAR VAL CWT[3]	0.11	<0.0001
YEAR[4]	0.03	<0.0001

[1]*Stepwise regression included 17 independent variables regarding growth, carcass traits, health, and economic data. Only significant variables (P<0.05) with a partial r^2 greater than 0.02 are listed.*
[2]*HCW, Hot Carcass Weight*
[3]*CAR VAL CWT, Carcass Value per hundred weight, the value of the carcass expressed in $/kg*
[4]*YEAR, the programmatic year in which the cattle were consigned to the Alabama Pasture to Rail Program*

TABLE 9.

MULTIPLE REGRESSION OF GROWTH, CARCASS, HEALTH, AND ECONOMIC METRICS ON THE DEPENDENT VARIABLE HOT CARCASS WEIGHT OF BEEF CATTLE ENROLLED IN THE ALABAMA PASTURE TO RAIL RETAINED OWNERSHIP PROGRAM[1]

INDEPENDENT VARIABLE	Partial r^2	P-value
ADG[2]	0.62	<0.0001
AL WT[3]	0.19	<0.0001
DOF[4]	0.14	<0.0001

[1]*Stepwise regression included 14 independent variables regarding growth, carcass traits, health, and economic data. Only significant variables (P<0.05) with a partial r^2 greater than 0.02 are listed.*
[2]*ADG, Average Daily Gain, Kg gain/dain*
[3]*AL WT, Individual weights of animals in Alabama prior to transportation to the feedyard, in kilograms.*
[4]*DOF, Days on Feed, number of days cattle were fed from feedyard arrival to slaughter*

Chapter 3: Growth performance, carcass characteristics, pathogen shedding, and hematology of weaned calves fed different backgrounding diets and transported to a southern plains feedyard

INTRODUCTION

The beef cattle industry in the southeastern U.S. is predominately a cow-calf system, with more than 4 million beef cows in Alabama, Mississippi, Georgia, Florida, Tennessee, North Carolina and South Carolina, or approximately 12.8% of the total U.S. cowherd (USDA-NASS, 2017). The vast majority of the calves born in this region are eventually transported to one of the major feeding regions of the U.S. to be finished and harvested. Transportation is stressful to the animal, especially when coupled with other stressors such as weaning, castration, commingling with new animals, and nutritional change during the same period (Carroll et al., 2007). These stressors can have negative impacts on performance and health of animals entering the feedyard (Carroll et al., 2007).

A widely accepted management strategy for cow-calf producers to reduce the risk of bovine respiratory disease and add value to their calf crop is to background or precondition the calf prior to shipping (Wilson et al., 2017). This backgrounding process typically includes weaning, vaccination against respiratory tract viruses and bacteria, and nutritional management aimed at supporting cost-efficient, moderate growth to prepare calves to be fed in a feedyard environment. For producers interested in backgrounding fall-born calves in the Southeastern U.S., this can be challenging with limited access to high quality forage options during the summer months. Forte et. al. (2018) demonstrated that drylot diets based around ryegrass baleage, bermudagrass hay, and corn silage can be effective options to fill this gap in forage

quality; however, research regarding the use of warm-season annual grasses in this southeastern backgrounding system is limited.

While there is published literature describing the positive attributes of backgrounding on the transition of beef calves into the stocker or feedyard phase, this work largely focuses on nutritional strategies used in the Midwestern U.S. for the post-weaning calf receiving period, backgrounding, and stocker calf management (Duff and Gaylean, 2007; Cox-O'Neill et al., 2017). Nutritional management practices of beef producers in the Southeast U.S. may influence animal performance, transition, and success in the feedyard phase. The objective of this study was to evaluate the effect of backgrounding diet on growth during the preconditioning period, and subsequent influence on transport stress, transition to the feedyard, and performance through animal harvest.

MATERIALS AND METHODS

All procedures for the study were approved by the Auburn University Institutional Animal Care and Use Committee for the use of live vertebrate animals in experiments (PRN 2018-3320).

Animals and Backgrounding Period

One hundred twenty Hereford- and Angus-sired steers (n = 60, 238 ± 22 kg BW) and heifers (n = 60, 228 ± 18 kg BW) were selected from the resident herd of the E.V. Smith Research Center (Shorter, AL) and weaned on June 14, 2018. At weaning calves were vaccinated with Bovi-Shield Gold (Zoetis Animal Health, Parisippany, New Jersey). Calves were housed in drylots and provided *ad libitum* access to bermudagrass hay and water for 14 d while awaiting summer annual forages to reach an adequate height for grazing. Steers and heifers were assigned

to dietary treatment groups such that each pen had equal numbers of each sex and average steer and heifer body weights across treatments were within 1 standard deviation of the overall sex mean body weight at weaning. Each treatment group was then assigned to one of four diets (3 pens per dietary treatment for a total of 12 pens). Backgrounding diets were: 1) drylot with *ad libitum* cool-season annual baleage [oat (*Avena sativa*), annual ryegrass (*Lolium multiflorum*) and crimson clover (*Trifolium incarnatum*)] and 1% of body weight (BW) dried distiller's grains with solubles (DDGS) fed daily (BS), 2) drylot with *ab libitum* bermudagrass hay and 1% of BW of DDGS fed daily (HS), 3) grazing mixed crabgrass (*Digitaria cilaris*) and signal grass (*Brachiaria decumbens*) pastures and 1% of BW of DDGS fed daily (**GS**), or 4) grazing mixed crabgrass and signal grass pastures with no supplemental feed provided (**GO**). Diets were selected and designed to reflect backgrounding management systems and feeding practices commonly used by beef producers in the Southeast U.S. region (Table 10). These practices include feeding supplement at a set level of allocation during the backgrounding phase and using conserved forage resources or seasonally available grazed forage which coincides with the weaning and backgrounding period. For drylot diets, conserved forage was fed in open-style metal hay rings, and feed supplements were fed in concrete bunks daily. Supplement amounts (kg/hd/d) were adjusted to achieve 1% BW after cattle weighing events which occurred on d 0 and 28 of the 60 d backgrounding trial. All Cattle had ad libitum access to water and mineral (Wind and Rain® All Season 7 Complete, Purina®, Shoreview, MN).

Forage Management and Animal Performance Measurements

Cool-season baleage was harvested from a single cutting of the mixture when oats reached the boot-to-early dough stage on April 13, 2018 and allowed to wilt for 24-h to achieve a moisture level of 40 to 60% prior to baling and wrapping. Moisture range of baleage prior to

baling was determined using a microwave test (Steevens et al., 1993). Baleage was wrapped using an in-line wrapper with six layers of polyethylene plastic with a 50% overlap and stored until the time of feeding. Tifton 85 bermudagrass was harvested from June through September 2017, and stored in a pole barn until the start of the backgrounding study in 2018. For each diet treatment that included conserved forage, samples were collected from each forage lot utilized for the study (Mullenix and Johnson, 2018), and analyzed for nutritive value. In each pen, bales were replaced every 5 to 7 d depending on bale wastage and refusal (42 and 36 total bales of baleage and hay used during the study, respectively).

For grazing-based diets, crabgrass was planted into a prepared seedbed on April 18, 2018 at a planting rate of 5.6 kg/ha and fertilized with 67 kg N/ha in mid-May. Seeding rate used according to Extension recommendations for central Alabama (Dillard et al., 2019). During pasture establishment, significant encroachment of broadleaf signalgrass was observed, and contributed to an estimated 50% of the pasture species composition at the initiation of the study. Pastures for grazing treatments were 2-ha each, and stocked at a fixed rate of 5 animals/ha. Pastures were subdivided into 1-ha paddocks using temporary electric fencing, and managed using a 14-d rotation during the study. On June 28, 2018, calves began an 8-d acclimation period on their respective dietary treatments before the 60-d backgrounding trial began on July 6, 2018. Initiation of the study began when forages became available for grazing and reached a height of 15 cm. An initial test body weight was collected in the morning for calves at the beginning of the study on July 8, 2018. Calves were weighed on August 3, 2018, the mid-point of the 60-d background trial, and at the end of the backgrounding phase on September 4, 2018. At this time, calves were re-vaccinated with Bovi-Shield Gold One Shot (Zoetis Animal Health, Parisippany, New Jersey).

Calves remained on their respective diets until September 17, 2018, when they were

transported to a feedyard in southwest KS to be fed until harvest. On the morning of September

17, 2018, calves were individually weighed, rectal swabs were collected for pathogen detection,

and blood was drawn for hematological analysis prior to transportation to the feedyard. Each pen

of calves was randomly assigned to one of two trucks. Calves were loaded onto trucks starting at

4 p.m. central standard time and transported approximately 1100 miles directly to the feedyard

without being unloaded during the transport. Calves arrived at the feedyard at approximately 7

a.m. on the morning of September 18, 2018.

Calves were immediately unloaded into a holding pen with no access to feed or water. At

this time, calves were visually appraised for any signs of lameness, sickness, or distress by the

research team and feedyard staff. Once deemed healthy enough to continue, calves were then

weighed, rectal swabs were collected for pathogen detection, and blood was drawn for

hematological analysis. After processing, calves were placed in two pens, remaining in their

groups by truck, and allowed to rest for 24 h with *ab libitum* access to water and hay.

After 24 h rest, calves were again weighed, rectal swabs were collected for pathogen

detection, blood was drawn for hematological analysis, and typical processing at feedyard entry

occurred. Feedyard entry processing included calves being: dewormed with an injectable

moxidectin (Cydectin, Bayer Healthcare, LLC, Shawnee Mission, Kansas) and an oral drench

oxfendazole (Synanthic, Boehringer Ingelheim Vetmedica, Inc., St. Joseph, Missouri),

vaccinated for Infectious Bovine Rhinotracheitis (Pyramid 3, Boehringer Ingelheim Vetmedica,

Inc., St. Joseph, Missouri), implanted with a growth promoting hormone implant (Component

TE-IS with Tylan, Elanco Animal Health, Greenfield, Indiana), prophylactically treated with tilmicosin (Micotil 300, Elanco Animal Health, Greenfield, Indiana), and tagged with a feedyard ear tag. Calves were then moved to their feeding pen, where all 120 calves were fed together until harvest.

Once moved to their feeding pen, the transition from hay to full feed began. Calves were started on a starter ration that was high in fiber and gradually moved up to a finishing ration over 28 d. The final finishing ration consisted predominately of steam-flaked corn, dried distiller's grains with solubles, and alfalfa hay with a balanced mineral supplement, tylosin phosphate (Tylan 100, Elanco Animal Health, Greenfield, Indiana), and monensin (Rumensin, Elanco Animal Health, Greenfield, Indiana) included. For the final 30 d, ractopamine hydrochloride (Optaflexx, Elanco Animal Health, Greenfield, Indiana) was included in the diet.

To measure performance in the feedyard, cattle were gathered and weighed after 7, 28, 55, and 105 d on feed. Average daily gains were calculated for each period. Due to facility limitations at the feedyard and to minimize stress on the finished cattle, final weights were not individually gathered, however the entire group was weighed prior to being transported to the processing facility. Final weights were estimated based on the actual individual hot carcass weights of the animals and the dressing percentage of the entire group. Therefore, final weights, overall average daily gains, and average daily gain in the final 132 d are estimates derived from this calculation.

Cattle Harvest

After 237 d on feed, calves were transported to a commercial beef processing facility in the area and harvested in a single group. Radio frequency ID tags on the calves were scanned in

the facility to track individual animal data, and visual eartags were also recorded for redundancy. Hot carcass weights (HCW) were collected on each animal prior to carcass chilling. After chilling for ~36 h, carcasses were ribbed between the 12th and 13th rib. Ribeye area, backfat thickness, marbling score, calculated yield grade (CYG), USDA Yield Grade, and USDA Quality Grade was recorded for each animal by plant and USDA-AMS personnel using a camera grading system.

Blood Collection

To understand if there was an effect on the immune system and its response to transportation stress due to the dietary treatment in the backgrounding phase, blood was collected via jugular venipuncture at weaning, prior to transportation to the feedyard, immediately post-transportation to the feedyard, and after 24 h rest following transportation to the feedyard. Blood was collected into 4.5 mL evacuated tubes containing ethylene diamine tetra-acetic acid (EDTA) (Vacutainer: Becton, Dickinson and Company, Franklin Lakes, NJ) for determination of complete blood count (CBC) using an automated hemocyotometer (Procyte Dx Hematology Analyzer; IDEXX Laboratories, Inc., Westbrook, ME) immediately after collection. Additionally, blood was collected into 10 mL evacuated tubes containing no additive (Vacutainer: Becton, Dickinson and Company, Franklin Lakes, NJ). Whole blood was then processed for serum collection using the procedure outlined by Sanchez et al. (2018). Blood allowed to clot at room temperature for 30 m, then centrifuged for 20 m at 1,500 x g to separate blood fractions. Serum was collected into microcentrifuge tubes and frozen on-site for later analysis. Also following procedures outlined by Sanchez et al. (2018), serum cytokine concentrations (IFN-γ and IL-6) were determined in duplicate by 2-plex custom sandwich-based chemiluminescence ELISA kit (Searchlight-Aushon BioSystems, Inc., Billerica, MA) according

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to the manufacturer's instructions. Intra- and inter-assay coefficients of variation were less than 9.1% and 15.6%, respectively.

Pathogen Shedding

To understand the any effects of background diet on fecal shedding of *Salmonella spp.* (SAL) and *Escherichia coli* O157:H7 (O157), 2 fecal swabs were taken rectally on each animal to collect feces for pathogen detection at weaning, prior to transportation to the feedyard, immediately post-transportation to the feedyard, after 24 h rest following transportation to the feedyard, and at harvest. At harvest, these swabs were collected after stunning, exsanguination, and electrical stimulation of the carcass, but prior to the first pathogen intervention step. Weaning and harvest samples were transported back to the microbiology labs in Upchurch Hall at Auburn University in Auburn, AL for processing, and all other samples were processed at the USDA-ARS Livestock Issues Research Unit in Lubbock, TX. At both locations, the same protocol was followed.

For *SAL* detection, one rectal swab placed in 9 mL of Tetrathionate (TT) Broth with iodine supplement and incubated at 37 °C for 20 - 24 h. A 10 µL loop of the incubated broth was transferred onto Xylose Lysine Tergitol-4 (XLT-4) and incubated at 37 °C for 20-24 h. Following incubation, phenotypical *SAL* colonies were noted and a phenotypic colony was streaked on a Triple Sugar Iron (TSI) slant to confirm the presence of *SAL*. 1 mL of TT broth sample was transferred to 9 mL Rappaport Vassiliadis (RV) broth enrichment and incubated at 42 °C for 20 to 24 h. Any samples that were found to be negative following the TT broth enrichment and XLT-4 plating were then streak plated out of RV broth enrichment on XLT-4 and incubated at 37 °C for 20 to 24 h. Again, any phenotypical *SAL* colonies were noted and a phenotypic colony was streaked on a TSI slant to confirm the presence of *SAL*.

For *Escherichia coli* detection, the other fecal swab was placed in 9 mL of buffered

peptone water (BPW) and incubated at 37 °C for 20 to 24 h. After incubation, a 10 µL loop of

the incubated broth was transferred onto chromogenic selective agar for *O157* (BD BBL

CHROMagar O157) and incubated at 37 °C for 20 to 24 h. Plates that exhibited mauve colonies

were considered positive and a single mauve colony was restreaked on to an additional

CHROMagar O157 plate and incubated at 37 °C for 20 to 24 h to isolate colonies and confirm

the presence of *O157*. Additionally, 1 mL of the BPW was also placed in 9 mL of tryptic soy

broth (TSB) and incubated 37 °C for 20 to 24 h to enrich the sample. All samples that were

deemed negative from the first streak plates were then streak plated out of the corresponding

TSB sample onto CHROMagar O157 and incubated at 37 °C for 20 to 24 h. Again, any plates

that showed mauve colonies were considered positive and a single mauve colony was restreaked

on to an additional CHROMagar O157 plate and incubated at 37 °C for 20 to 24 h to isolate

colonies and confirm the presence of *O157*.

Statistical Analysis

Dietary treatments were arranged in a completely randomized design. Pen during the

backgrounding phase as the experimental unit for all variables and dietary treatment was the

fixed effect. Data were analyzed using GLIMMIX feature in SAS 9.4 (SAS Institute, Inc., Cary,

NC). Continuous variables were subjected to analysis of variance using the least squared means

syntax for Gaussian distributions with an R-side covariance structure. These continuous variables

included body weight (BW), average daily gain (ADG), hot carcass weight (HCW), *longissimus*

dorsi cross sectional area (REA), marbling score (MARB), backfat thickess (BF), calculated

USDA Yield Grade (CYG), and all hematological parameters. Microbiological data, percentage

of carcass that reached USDA Prime or Choice and percentage of carcasses that were USDA

Yield Grades 1-3 were coded into a binomial variables (1 = positive, 0 = negative) by individual animal. This binomial data was analyzed similarly using GLIMMIX feature of SAS 9.4 (SAS Institute, Inc, Cary, NC) for analysis of variance for binominal distributions and LOGIT link function with an R-side covariance structure. For each variable diet by time interactions were analyzed. If there was no significant interaction, then diet within time period was reported. Least square means were separated using the PDIFF function and standard of the collective means are reported. Alpha was set at 0.10 to determine significance to detect greater differences between terms due to the relatively small sample size (n = 3 pens for each diet). For analysis of Interleukin-6, samples greater than 3 standard deviations from the mean for each time × diet group were considered outliers and removed from the data set.

RESULTS AND DISCUSSION

Backgrounding Period

Table 11 shows the mean calf performance during the backgrounding period of the study by dietary treatment. Reported in the table is the effect of diet, only. Date had a significant effect ($P < 0.01$) with each date being heavier than the date prior. However there was not a significant interaction between diet and date for BW ($P = 0.17$). Diet ($P < 0.01$) and first versus second half of the back grounding period ($P = 0.01$) had a significant effect on ADG. The interaction between diet and ADG in the first 28 d or second 32 d of the backgrounding period was also significant ($P < 0.01$) and is reported in Table 11. Additionally, overall ADG during the backgrounding period differed among diets ($P < 0.01$) and is reported in Table 11.

Body weight (BW) was not different among dietary treatments at d 0 ($P = 0.22$). During the first 28-d of the backgrounding period, ADG differed among treatments ($P < 0.01$). Calves

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grazing crabgrass with supplemental feed (GS) had greater ADG during the first 28 d than conserved forage-based systems (BS and HS) ($P < 0.10$), while grazing crabgrass only (GO) had greater gains than BS calves ($P = 0.02$), but were not different than GS or HS calves ($P > 0.10$). However, at d 28 mean BW of calves did not differ among treatments ($P = 0.53$). During the second half of the backgrounding period, ADG was significantly reduced for both grazing based treatments (GO and GS) and was significantly increased for drylot groups (BS and HS) ($P < 0.10$). Additionally in the second 32 d period, all groups receiving DDGS supplementation had greater ADG than GO calves ($P < 0.01$) and these supplemented groups were not different than each other in that period ($P > 0.10$). When analyzing the data from the entire 60 d backgrounding period, diets using supplemental feed in addition to the forage base had similar ADG ($P > 0.10$) and all supported greater gain than the GO group ($P < 0.01$). This, in turn, led to GO calves having the lightest BW at the end of the 60 d period ($P < 0.01$), with all supplemented groups being heavier and not different than one another ($P > 0.10$).

Profitability for stocker and backgrounding systems largely depends on performance and achieving gains of at least 0.68 kg/d (Ball et al., 2015), and all diets containing supplementation achieved that threshold; however, GO calves did not over the entire length of the backgrounding period. Reduced performance in the second half of the backgrounding period for the GO treatment can likely be attributed, in part, to reduced forage quality later in the growing season. Under the fixed stocking rate used in the study, forage mass increased from June through August across grazed forage systems (mean 3,598 kg/ha to 9,228 kg/ha) and forage quality decreased (mean CP of 16.4% to 10.8% CP on a DM basis). This reduction in quality throughout the season is consistent with research on forage quality of crabgrass by others throughout the southeast (Ogden et al., 2005; Teutsch et al., 2005; Gelley et. al., 2016). By harvesting crabgrass in regular

intervals and keeping it a vegetative state, forage quality could potentially be preserved deeper in to the growing season (Beck, et al., 2007), indicating that moving to a grazing system that includes frequent rotation of paddocks might improve season long forage quality and, in turn, improve calf performance throughout the backgrounding period as compared to the 14 d two paddock rotational grazing system employed in this study. Research in grazing crabgrass for growing cattle is limited and further work is necessary to understand how to manage crabgrass to maintain adequate gains in backgrounding systems.

Transportation, Feedyard Performance and Carcass Merit

The effect of diet on post-transportation shrink and recovery is not well understood. The literature would indicate that the effect of diet during this time is variable (Coffey et al., 2001) and it was also noted that there is usually large individual animal variation with respect to shrink (Starnes et al., 2013). Calf performance responses following transport to southwest Kansas are presented in Table 12. Diet and date both had a significant effect on BW ($P < 0.01$), but the interaction of diet by date was not significant ($P = 0.98$). Calves backgrounded on the grazing only system were lower in BW compared to BS, GS, and HS calves at the pre-transport weigh period ($P < 0.01$), and this pattern was observed for BW on arrival to the feedyard ($P < 0.01$) and 24-hr post-transport ($P < 0.01$).

When analyzing BW shrink, diet and date both had a significant effect ($P < 0.01$), but the interaction of diet and date was not significant ($P = 0.28$). Immediately after transportation with no rest, GO calves had the greatest shrink value compared to all other treatments ($P < 0.01$) with none the other treatments being different ($P > 0.10$). After 24 h rest, HS and GO calves had greater shrink when compared to GS calves ($P = 0.02$), while BS calves we not different that any

other diet group ($P > 0.10$). After 7 d on feed, GS calves had recovered the greatest percentage of their pre-transport BW compared to all other treatment groups ($P < 0.01$), which did not differ from one another ($P > 0.10$). Shrink is not only the loss of gut fill over time, but also the loss of body tissue and fluid (Coffey et al., 2001). By allowing animals to rest 24 with free choice access to water and hay, shrink at that point could indicate differences in body tissue loss during shrink and/or adaptation to the feedyard environment. With the lowest shrink value at 24 h rest and the greatest percentage of pre-transportation body weight recovered, it can be assumed that the GS calves performed better than the other dietary groups relative to the transportation event.

Table 13 highlights the performance of the calves during the feeding period after arrival at the feedyard and the carcass data from the calves after harvest. Diet and weigh date both a significant effect on BW ($P < 0.10$), but there was no diet by weigh date interaction effect ($P = 0.97$). At no point during the feeding period were there differences in BW between any of the groups that received supplemental feed during the backgrounding period ($P > 0.10$). Similar to what was observed at the end of the backgrounding period and throughout transportation, GO calves had lighter BW than all supplemented groups at d 7 ($P < 0.01$) and d 28 ($P < 0.01$). At d 55, differences in BW were no longer significant through the remaining time in the feedyard ($P > 0.10$).

ADG was calculated for each period of time between weigh dates to observe the changes in growth by calves during shorter periods of time. All mean ADGs were analyzed together to determine if a period by diet interaction occurred. This interaction did not have a significant effect ($P = 0.26$). Data was re-analyzed to determine differences by diet at each growth period. While no differences were detected in ADG from d 0 through d 7 ($P = 0.19$), GO calves had greater ADG during the period from d 7 through d 28 when compared to all supplemented

groups ($P = 0.05$), potentially exhibiting compensatory gain due to the lack of performance during the backgrounding period. After d 28, no differences were seen in ADG between groups at any time interval including ADG for the entire 237 d feeding period ($P > 0.10$).

Similar to BW and ADG in the later portion of the feedyard phase, no differences were observed for hot carcass weight (HCW, $P = 0.40$), ribeye area (REA, $P = 0.41$), marbling score ($P = 0.89$), percentage of carcasses grading USDA Choice or Higher ($P = 0.66$), calculated USDA Yield Grade (CYG, $P = 0.92$), and backfat thickness ($P = 0.89$). Only the percentage of carcasses that graded USDA Yield Grade 1, 2, or 3 were different ($P = 0.05$). The greatest percentage was in BS calves which were not different that GS calves ($P > 0.10$), but was greater than HS and GO calves ($P < 0.10$). GS calves were not different than HS calves ($P > 0.10$), but were greater than GO calves ($P < 0.10$). GO calves had the lowest percentage of YG 1, 2, or 3 carcasses, but were not different than HS calves ($P > 0.10$).

In measured feedyard performance and carcass-related metrics, calf performance differences in the backgrounding phase were diminished in magnitude through animal harvest. This data aligns with research from other published trials demonstrating that dietary treatment in the backgrounding phase has negligible effects on long-term feedyard performance and carcass characteristics (Loken, et al, 2009; Kumar et al., 2012; Gadberry et al., 2012; Lancaster et al., 2014). Differences in HCW, REA, marbling score, and percent Choice based on backgrounding diets of corn residue grazing, cover crop grazing, or drylot backgrounding methods, were reported by Cox O'Neill et al. (2017) but the magnitude of these differences were less than those in this study and likely were detected because of much larger sample size.

Complete Blood Counts and Inflammatory Cytokines

Red blood cell count (RBC), hemoglobin concentration (HGB), and hematocrit percentage (HCT) data from blood collections at weaning and around the transportation event are presented in Table 14. RBC differed by diet ($P < 0.01$), sampling date ($P < 0.01$) , and there was a significant diet by date interaction ($P < 0.01$). This interaction is shown in Table 14. There were no differences between diets at weaning ($P > 0.10$). For all diets, RBC increased from pre-transportation levels immediately after transportation before any rest ($P < 0.10$). GO calves had the lowest RBC at all time points surrounding the transportation event ($P < 0.10$), when compared to BS, HS, and GS calves. Only BS calves returned to pre-transportation RBC after 24 h rest ($P > 0.10$). There was no diet by time interaction for HGB ($P = 0.11$) and only the effect of diet within time point is reported in Table 14. There were no differences by diet at weaning ($P = 0.42$). At each time point surrounding the transportation event, RBC was lowest for GO calves ($P < 0.01$), however all supplemented groups were not different from one another ($P > 0.10$). HCT differed by diet ($P < 0.01$), sampling date ($P < 0.01$), and there was a significant diet by date interaction ($P < 0.01$). Diet by date interaction is reported in Table 14. There were no differences between dietary groups at weaning ($P > 0.10$). At each time point, GO calves had lower HCT ($P < 0.10$) than supplemented groups and supplemented groups were not different from one another ($P > 0.10$). All dietary groups greater HCT immediately post-transportation compared to pre-transportation concentrations ($P < 0.10$). After 24 h of rest, only BS had HCT that was not greater than pre-transportation concentrations ($P > 0.10$). While differences were observed for blood count responses due to nutritional strategy during the backgrounding phase, all reported averages fell within or just above reference ranges found in the literature for beef cattle (George et al., 2010; Roland et al., 2014). Differences in RBC, HGB, and HCT on the scale seen in this study could be ascribed to blood-loss (Merdana et al., 2020), however that can

be ruled out in this study. Hematocrit can be used as an indicator of hydration status, with increased HCT shown when water is withheld from cattle (Schaefer et al., 1990). Research in the area of dietary impacts on hydration around transportation is limited. In this study, GO calves had consistently lower HCT, which could indicate a better hydration status for calves in that treatment group relative to supplemented groups. Overall, this data from this study agrees with other studies that transportation can cause an increase in HCT (Ali-Gholi et al., 2007; Bernardini et al., 2012)

Increased white blood cell (WBC), neutrophil concentration (NEU), and decreased lymphocyte concentration (NEU) are all commonly observed changes in calves in response to stress (Earley et al., 2017). These parameters serve as an indicator of immune response with WBC representing total count of all leukocyte subpopulations (Roland et al., 2014), neutrophils being an important component of the innate immune system, and lymphocytes being a key component of the adaptive immune system (Carroll et al., 2007). Differences in WBC, NEU, LYM, and neutrophil-to-lymphocyte ratio (N:L) for each dietary treatment are presented in Table 15. There was no diet by sampling date interaction for WBC ($P = 0.53$), so WBC means were analyzed for differences within each sampling date. WBC were not different at weaning ($P > 0.10$), however WBC did differ prior to transportation, where HS and BS calves had greater counts than GS calves ($P < 0.10$) and GO calves were not different than BS or GS calves ($P > 0.10$), but were smaller to HS calves ($P < 0.10$). Immediately after transportation, HS calves had greater WBC than all other calves ($P < 0.10$), and BS calves had greater concentrations that GO calves ($P < 0.10$), while GS calves were not different than either BS or GO calves ($P > 0.10$).

Diet ($P < 0.01$), sampling date ($P < 0.01$), and the interaction between diet and date ($P = 0.07$) all had a significant effect on NEU. The interaction between the two terms is presented in

Table 15. There were no differences between diets at weaning or before transportation ($P > 0.10$). All dietary treatments had an increase in NEU from pre-transportation to immediately post-transportation ($P < 0.10$) and all diets had NEU after 24 h of rest that were not different than pre-transportation level within diet ($P > 0.10$, but there were differences in response to transportation between diets. Immediately post-transportation, HS calves had the greatest NEU compared to all others treatments ($P < 0.10$) and GO calves has the lowest NEU of all treatments ($P < 0.10$). BS and GS calves were not different from one another ($P > 0.10$) post-transportation. After 24 h rest, GO calves had the lowest NEU ($P < 0.10$), while all supplemented groups were not different from one another ($P > 0.10$).

Diet ($P = 0.02$) and sampling date ($P < 0.01$) had a significant effect on LYM, but the interaction of diet and sampling date was not significant ($P = 0.32$). As such, the differences between diets within sampling date are reported in Table 15. Prior to transportation, BS and HS calves had the greatest LYM compared to GS calves ($P < 0.10$). GO calves were not different from HS or GS calves ($P > 0.10$). Immediately after transportation, lymphocyte concentrations were reduced, but there were no difference between treatments ($P = 0.20$). Following 24 h rest, BS and GO calves had the greatest LYM compared to other diets ($P < 0.10$) with GS calves having the lowest LYM ($P < 0.10$). HS calves were not different from GO or GS calves after 24 h rest ($P > 0.10$).

Diet ($P < 0.01$) and sampling date ($P < 0.01$) had a significant effect on N:L as was the interaction of diet and sampling date ($P = 0.02$). In Table 15, the interaction is presented. There were no differences between diet at weaning ($P > 0.10$), nor between diets pre-transportation ($P > 0.10$). All diets exhibited an increase in N:L from pre-transportation to post-transportation ($P < 0.10$), but at different levels. HS calves had the greatest N:L post-transportation ($P < 0.10$) and

GO calves had the least ($P < 0.10$). After 24 h rest, BS and GO calves' N:L were not different than pre-transportation ratios ($P > 0.10$), however HS and GS calve were still elevated compared to pre-transport ratios ($P < 0.10$) and compared to BS and GO calves after 24 h of rest ($P < 0.10$).

While differences were observed between treatments, all reported averages fell within or just above reference ranges found in the literature for beef cattle (George et al., 2010; Roland et al., 2014). Differences seen in NEU, LYM, and N:L dietary treatment groups indicate that differences in diet created variable responses to transportation stress in innate and adaptive immunity. The increase in NEU and decrease in LYM immediate post transportation seen in this study agrees with what has been previously reported in the literature (Swanson et al., 2001; Sporer et al., 2007). Hulbert et al. (2011) observed a similar response to transportation, where N:L increases after transportation then returns to pre-transportation baseline over time. As neutrophils are a primary component of the innate immune system and lymphocytes a primary component of the acquired immune system (Carroll et al., 2007), this increase in NEU would be indicative of animals responding to stress and preparing for a challenge to their homeostasis. The subdued increase in NEU for GO calves could be indicative of a less responsive immune system possibly due to the stress of transportation combined with poor performance and sub-optimal nutritional plane through the backgrounding period. However there were no differences in number of calves treated for respiratory disease by feedyard or death-loss between dietary groups ($P > 0.10$, not reported in tables).

Concentrations of the inflammatory cytokines Interleukin-6 (IL-6) and Interferon- γ (IFN-γ) in blood serum collected at various time points are listed in Table 16. No differences were detected between dietary treatments at any time point for either IL-6 or IFNγ ($P > 0.10$),

giving no additionally clarity of the effect of these diets on the status of the pro- or anti-inflammatory response to transportation stress.

Pathogen Shedding

Fecal shedding of SAL and O157 was measured and the percentage of animals testing positive for each diet at weaning, prior to transportation, immediate after transportation with no rest, after 24 h rest, and at harvest prior to any harvest microbial interventions is displayed in Table 17. While sampling date had a significant effect on the detection of SAL ($P < 0.01$), dietary treatment did not have an effect ($P > 0.10$). SAL detection in live animals is variable. Dewell et al. (2008) observed that hides swabs at the time of harvest ranged from 5% to 95% of animals in individual lots of cattle cultured positive for SAL. Detection of SAL at harvest in feces in this study is consistent with other studies (Barham et al., 2002; Beach et al., 2002) as well as the increase in SAL fecal shedding (Barham et al., 2002; Beach et al., 2002) and on hides post-transportation (Barham et al., 2002; Reicks et al., 2007; Arther et al., 2008). However, most research surrounding transportation is from the feedyard to slaughter and not from the farm of origin. Detection of SAL has been shown to be seasonal, with detection increasing from spring through highs in the summer and fall, before decreasing in the winter (Barkocy-Gallahar et al., 2003; Rivera-Betancourt et al., 2003). With this study, detection of SAL was greatest in the spring at harvest. This could be indicative the relative naivety of these calves coming into the feedyard, as compared to these same calves after 237 d on feed. After 24 h of rest after transportation, BS calves were shedding of *O157* at the greatest percentage compared to the other three treatments ($P = 0.06$). There were no differences in *O157* shedding at any other time point ($P > 0.10$). There was no interaction between diet and sampling date ($P = 0.45$).

CONCLUSIONS

All four backgrounding diet systems provided to newly weaned calves in this project supported growth through the summer months. For producers weaning fall-born calves in late spring and summer, forage-based diets using supplementation supported overall gains of 0.74 kg/d or greater during the study, which aligns with desired performance characteristics suggested by extension publications of a minimum 0.68 kg/d (Ball et al., 2015). Grazing alone could potentially be an effective option, as was shown in the early portion of the backgrounding period, but more intensive grazing management and management to create additional early growing-season utilization may be necessary to minimize the negative effects of declining forage quality on performance. This data would also suggest that diet during the backgrounding phase has greater impact on the beef production system than just the performance of that brief period.

With as many as 75% of all feedyard animals that must be treated for respiratory disease being first treated within 40 d of arrival (Avra et al., 2017), improvements in adaptation and increased feed intake at feedyard entry are critical to minimizing early disease issues and reducing morbidity and mortality (Wolfger et al., 2015). In this study, backgrounding diet affected shrink and early feedyard performance. Preconditioning diet creates differences in basic hematology and pathogen shedding of growing beef cattle surrounding the transportation event, although the pattern of this response is not well understood. Further research is necessary to understand how this interaction occurs and if there are real-world applications that can made to the backgrounding dietary management of beef calves to have positive impact on animal health, performance, and beef system food safety.

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Table 10. Forage production and chemical composition characteristics of conserved or grazed forages and co-product supplements fed during a 60-d backgrounding trial for weaned beef calves.

Item	CSB[1]	BH	CG-NS	CG-S	DDGS
Moisture, % as fed	61.2	14.3	--	--	10.9
Nutrient Analysis[2]					
CP	11.1	7.9	9.9	16.2	24.8
NDF	56.4	79.7	--	--	32.4
ADF	31.5	44.9	--	--	10.7
Mean Forage Mass (kg ha^{-1})	--	--	8,303	7,639	--
Mean Bale Weight (kg)	816	482	--	--	--

[1]CSB = cool-season annual baleage harvested in the boot-to-early dough stage; BH = Tifton 85 bermudagrass hay; CG-NS = crabgrass/signalgrass pastures with no supplement; CS-S = crabgrass/signalgrass pastures with 1% of animal body weight per day supplementation with DDGS; DDGS = dried distillers grains with solubles, respectively.
[2]Values reported on a % DM basis

Table 11. Mean body weight (kg) and mean average daily gain (kg/d) of calves during a 60-d backgrounding period using conserved forage or grazing-based systems.

Body Weight, kg	Diet[1]					
	BS	HS	GS	GO	SEM	*P*
D 0	248.5	255.5	242.8	248.0	4.2	0.22
D 28	266.2	274.7	268.0	270.6	4.2	0.55
D 60	293.3[a]	301.8[a]	291.9[a]	277.0[b]	4.4	0.02

ADG, kg/d[2]	Diet					
	BS	HS	GS	GO	SEM	*P*
D 0 to 28	0.63[h]	0.68[gh]	0.90[e]	0.81[efg]	0.05	0.01
D 28 to 60	0.84[ef]	0.84[ef]	0.74[fg]	0.19[i]		

ADG, kg/d	Diet					
	BS	HS	GS	GO	SEM	*P*
Overall	0.74[a]	0.77[a]	0.81[a]	0.48[b]	0.03	<0.01

[abc]Within a row, means without common superscripts differ ($P < 0.10$).

[efghi]Within section of the table, means without common superscripts differ ($P < 0.10$)

[1]Backgrounding period diets are defined as BS = Oat, annual ryegrass and crimson clover baleage with 1% of animal body weight per day of dried distillers grains; HS = Bermudagrass hay with 1% of animal body weight per day of dried distillers grains; GS = Crabgrass/signalgrass grazing with 1% of animal body weight per day of dried distillers grains; GO = Crabgrass/signalgrass grazing without supplemental feed.

[2]Interaction of Diet by Time

Table 12. Calf body weight and percentage of body weight shrink loss following transport from Shorter, AL to the feedyard in Montezuma, KS.

Body Weight, kg	Diet[1]					
	BS	HS	GS	GO	SEM	*P*
Pre-Transport[2]	294.2[a]	301.7[a]	291.2[a]	269.7[b]	4.4	<0.01
Post-Transport[3]	273.4[a]	278.1[a]	269.8[a]	243.2[b]	4.1	<0.01
24 h Rest[4]	283.9[a]	287.8[a]	284.1[a]	256.2[b]	4.6	<0.01

Shrink Loss (% of Animal Body Weight)	Diet					
	BS	HS	GS	GO	SEM	
%, Post-Transport	7.0[b]	7.9[b]	7.3[b]	9.8[a]	0.4	<0.01
%, 24 h Rest	3.4[ab]	4.7[a]	2.4[b]	5.0[a]	0.6	0.02
%, D 7 Recovery[5]	94.8[b]	94.8[b]	97.6[a]	93.6[b]	0.6	<0.01

[abc]Means within the same row with different superscripts are significantly different($P < 0.10$)
[1]Backgrounding period diets are defined as BS = Oat, annual ryegrass and crimson clover baleage with 1% of animal body weight per day of dried distillers grains; HS = Bermudagrass hay with 1% of animal body weight per day of dried distillers grains; GS = Crabgrass/signalgrass grazing with 1% of animal body weight per day of dried distillers grains; GO = Crabgrass/signalgrass grazing without supplemental feed.
[2]Pre-Transport observations are those taken immediately before calves were loaded for transportation from Shorter, AL to Montezuma, KS
[3]Post-Transport observations are those taken immediately after arrival at the feedyard in Montezuma, KS without rest, feed, or water.
[4]24 h Rest observations are those taken after animals were allowed to rest with access to hay and water for 24 h after arrival.
[5]D 7 Recovery is the percentage of the Pre-Transport Body Weight recovered by d 7 on feed.

Table 13. Calf feedyard performance and carcass characteristics when backgrounded using conserved forage or grazing-based systems.

Body Weight, kg	Diet[1]					
	BS	HS	GS	GO	SEM	*P*
D 0	283.9[a]	287.8[a]	284.1[a]	256.2[b]	4.6	<0.01
D 7	278.7[a]	285.2[a]	284.2[a]	252.4[b]	4.5	<0.01
D 28	322.6[a]	333.1[a]	326.9[a]	303.3[b]	5.2	<0.01
D 55	373.2	373.3	382.0	355.3	8.1	0.16
D 105	453.3	461.1	466.3	440.0	8.3	0.14
Final	614.1	621.2	636.9	607.3	12.8	0.40
ADG, kg/d	Diet					
	BS	HS	GS	GO	SEM	*P*
D 0-7	-0.75	-0.27	0.00	-0.54	0.25	0.19
D 7-28	2.09[b]	2.19[b]	2.03[b]	2.51[a]	0.12	0.05
D 28-55	1.88	1.49	2.00	1.93	0.25	0.48
D 55-105	1.58	1.76	1.68	1.73	0.17	0.87
D 105-237	1.22	1.22	1.32	1.27	0.06	0.64
Overall	1.39	1.40	1.49	1.49	0.05	0.13
Carcass	Diet					
	BS	HS	GS	GO	SEM	*P*
HCW, kg	394.6	399.2	409.3	390.3	8.2	0.40
REA, sq. cm[2]	94.92	90.40	95.96	92.74	2.52	0.41
Marbling[3]	469	450	466	465	19	0.89
% Choice[4]	81.5	70.4	82.8	74.1	8.2	0.66
CYG[5]	3.14	3.28	3.22	3.29	0.17	0.92
% YG 1-3[6]	92.6[a]	74.1[bc]	89.7[ab]	66.7[c]	7.4	0.05
Backfat, cm[7]	1.57	1.64	1.57	1.64	0.09	0.89

[abc]Means within the same row with different superscripts are significantly different ($P < 0.10$).

[1]Backgrounding period diets are defined as BS = Oat, annual ryegrass and crimson clover baleage with 1% of animal body weight per day of dried distillers grains; HS = Bermudagrass hay with 1% of animal body weight per day of dried distillers grains; GS = Crabgrass/signalgrass grazing with 1% of animal body weight per day of dried distillers grains; GO = Crabgrass/signalgrass grazing without supplemental feed.

[2]REA is the area of the *L. dorsi* in square centimeters at the break between the 12th and 13th rib

of the carcass.

[3]Marbling Score 300-399= Slight 400-499= Small 500-599=Modest degree of marbling in the *L. dorsi* when observed at the break between the 12th and 13th rib.

[4]Percentage of carcasses that were graded USDA Choice or USDA Prime

[5]The unrounded calculated USDA Yield Grade

[6]Percentage of carcasses that were graded USDA Yield Grade 1, 2, or 3.

[7]Thickness of the subcutaneous fat at the break between the 12th and 13th rib, measured in centimeters

Table 14. Red blood cell count, hemoglobin concentration, and hematocrit percentage following transportation from Shorter, AL to Montezuma, KS of calves fed different backgrounding diets.

Red Blood Cells	Diet[1]					
Million cells/µL	BS	HS	GS	GO	SEM	*P*
Weaning[2]	10.01^e	9.76^{ef}	10.26^e	9.82^{ef}		
Pre-Transport[3]	8.73^h	8.75^h	9.10^{gh}	7.27^j	0.18	<0.01
Post-Transport[4]	9.41^{fg}	9.66^{ef}	10.04^e	8.06^i		
24 h Rest[5]	9.00^{gh}	9.41^{fg}	9.77^{ef}	7.85^i		
Hemaglobin	Diet					
Grams/dL	BS	HS	GS	GO	SEM	*P*
Weaning	13.05	12.66	13.15	12.81	0.22	0.42
Pre-Transport	12.01^a	11.60^a	11.66^a	9.80^b	0.21	<0.01
Post-Transport	12.96^a	12.79^a	12.86^a	10.84^b	0.20	<0.01
24 h Rest	12.39^a	12.36^a	12.43^a	10.52^b	0.19	<0.01
Hematocrit	Diet					
Percentage	BS	HS	GS	GO	SEM	*P*
Weaning	39.83^e	38.57^{ef}	40.38^e	38.83^e		
Pre-Transport	36.28^{fg}	34.59^g	34.94^g	26.26^i	0.79	<0.01
Post-Transport	40.16^e	39.46^e	40.06^e	32.32^h		
24 h Rest	38.47^{ef}	38.73^e	39.02^e	31.61^h		

^{abc}Means within the same row with different superscripts are significantly different ($P < 0.10$).
^{efghij}Means within the same section of the table with different superscripts are significantly different ($P < 0.10$).
[1]Backgrounding period diets are defined as BS = Oat, annual ryegrass and crimson clover baleage with 1% of animal body weight per day of dried distillers grains; HS = Bermudagrass hay with 1% of animal body weight per day of dried distillers grains; GS = Crabgrass/signalgrass grazing with 1% of animal body weight per day of dried distillers grains; GO = Crabgrass/signalgrass grazing without supplemental feed.
[2]Weaning observations are those taken at weaning prior to the beginning of dietary treatments.
[3]Pre-Transport observations are those taken immediately before calves were loaded for transportation from Shorter, AL to Montezuma, KS
[4]Post-Transport observations are those taken immediately after arrival at the feedyard in Montezuma, KS without rest, feed, or water.
[5]24 h Rest observations are those taken after animals were allowed to rest with access to hay and water for 24 h after arrival. [5]D 7 Recovery is the percentage of the Pre-Transport Body Weight recovered by d 7 on feed

Table 15. White blood cell, neutrophil, and lymphocyte counts and neutrophil to lymphocyte ratio following transportation from Shorter, AL to Montezuma, KS of calves fed different backgrounding diets.

White Blood Cells Thousand Cells/ µL	Diet[1]					
	BS	HS	GS	GO	SEM	*P*
Weaning[2]	13.65	13.42	12.55	13.39	0.55	0.54
Pre-Transport[3]	12.09^{ab}	12.51^a	11.04^c	11.37^{bc}	0.37	0.07
Post-Transport[4]	13.56^b	14.90^a	13.32^{bc}	12.15^c	0.48	0.02
24 h Rest[5]	12.22	12.05	11.09	11.24	0.43	0.22
Neutrophils	Diet					
Thousand Cells/ µL	BS	HS	GS	GO	SEM	*P*
Weaning	4.40^h	4.46^{gh}	3.82^{hij}	4.16^{hi}		
Pre-Transport	2.52^{lm}	3.15^{jkl}	2.60^{lm}	2.58^{lm}	0.30	0.07
Post-Transport	6.24^f	7.91^e	6.47^f	5.17^g		
24 h Rest	2.92^{kl}	3.56^{ijk}	2.92^{kl}	2.04^m		
Lymphocytes	Diet					
Thousand Cells/ µL	BS	HS	GS	GO	SEM	*P*
Weaning	7.33	7.09	6.98	7.20	0.26	0.79
Pre-Transport	8.34^a	8.16^{ab}	7.28^c	7.62^{bc}	0.26	0.07
Post-Transport	6.26	5.76	5.71	5.77	0.19	0.20
24 h Rest	7.81^a	7.04^{bc}	6.75^c	7.50^{ab}	0.26	0.08
Neu:Lym	Diet					
Ratio	BS	HS	GS	GO	SEM	*P*
Weaning	0.64^{hi}	0.66^h	0.55^{hij}	0.58^{hi}		
Pre-Transport	0.32^{lm}	0.40^{kl}	0.36^{lm}	0.32^{lm}	0.05	0.02
Post-Transport	1.04^f	1.42^e	1.15^f	0.91^g		
24 h Rest	0.38^{lm}	0.53^{ij}	0.44^{jk}	0.27^m		

^{abc}Means within the same row with different superscripts are significantly different ($P < 0.10$).
^{efghijklm}Means within the same section of the table with different superscripts are significantly different ($P < 0.10$)
[1]Backgrounding period diets are defined as BS = Oat, annual ryegrass and crimson clover baleage with 1% of animal body weight per day of dried distillers grains; HS = Bermudagrass hay with 1% of animal body weight per day of dried distillers grains; GS =

Crabgrass/signalgrass grazing with 1% of animal body weight per day of dried distillers grains; GO = Crabgrass/signalgrass grazing without supplemental feed.

[2]Weaning observations are those taken at weaning prior to the beginning of dietary treatments.

[3]Pre-Transport observations are those taken immediately before calves were loaded for transportation from Shorter, AL to Montezuma, KS

[4]Post-Transport observations are those taken immediately after arrival at the feedyard in Montezuma, KS without rest, feed, or water.

[5]24 h Rest observations are those taken after animals were allowed to rest with access to hay and water for 24 h after arrival. [5]D 7 Recovery is the percentage of the Pre-Transport Body Weight recovered by d 7 on feed.

Table 16. Inflammatory cytokine concentrations following transportation from Shorter, AL to Montezuma, KS of calves fed different backgrounding diets.

Interleukin-6 Pg/mL	Diet[1]					
	BS	HS	GS	GO	SEM	*P*
Weaning[2]	69.9	111.5	114.5	35.5	28.3	0.23
Pre-Transport[3]	319.8	272.3	263.6	243.7	53.3	0.78
Post-Transport[4]	449.7	281.4	343.7	438.7	79.0	0.42
24 h Rest[5]	213.4	146.1	147.2	156.3	31.2	0.40

Interferon-γ Pg/mL	Diet					
	BS	HS	GS	GO	SEM	*P*
Weaning	40.8	56.3	32.7	54.0	14.5	0.64
Pre-Transport	11.4	8.7	7.4	9.5	1.7	0.48
Post-Transport	16.7	8.4	10.4	24.9	5.7	0.24
24 h Rest	10.7	7.7	4.2	11.0	2.8	0.35

[abc]Means within the same row with different superscripts are significantly different ($P < 0.10$).
[1]Backgrounding period diets are defined as BS = Oat, annual ryegrass and crimson clover baleage with 1% of animal body weight per day of dried distillers grains; HS = Bermudagrass hay with 1% of animal body weight per day of dried distillers grains; GS = Crabgrass/signalgrass grazing with 1% of animal body weight per day of dried distillers grains; GO = Crabgrass/signalgrass grazing without supplemental feed.
[2]Weaning observations are those taken at weaning prior to the beginning of dietary treatments.
[3]Pre-Transport observations are those taken immediately before calves were loaded for transportation from Shorter, AL to Montezuma, KS
[4]Post-Transport observations are those taken immediately after arrival at the feedyard in Montezuma, KS without rest, feed, or water.
[5]24 h Rest observations are those taken after animals were allowed to rest with access to hay and water for 24 h after arrival. [5]D 7 Recovery is the percentage of the Pre-Transport Body Weight recovered by d 7 on feed.

Table 17. Fecal shedding of *Salmonella spp.* and *Escherichia coli* O157:H7 at various time points in the life of calves fed different backgrounding diets and transported from Shorter, AL to a feedyard in Montezuma, KS.

Salmonella spp. Percent Positive	Diet					
	BS	HS	GS	GO	SEM	*P*
Weaning[2]	0.0	3.3	0.0	6.7	2.9	0.35
Pre-Transport[3]	0.0	0.0	0.0	0.0	0.0	NA
Post-Transport[4]	0.0	0.0	0.0	0.0	0.0	NA
24 h Rest[5]	10.0	26.7	23.3	20.0	7.3	0.45
Harvest[6]	37.0	20.8	20.7	29.6	8.6	0.51
E. coli **O157:H7** Percent Positive	Diet					
	BS	HS	GS	GO	SEM	*P*
Weaning	30.0	36.7	43.3	40.0	8.9	0.75
Pre-Transport	0.0	0.0	0.0	0.0	0.0	NA
Post-Transport	0.0	0.0	0.0	0.0	0.0	NA
24 h Rest	15.4[a]	0.0[b]	0.0[b]	3.3[b]	3.6	0.06
Harvest	100.0	100.0	100.0	96.3	1.9	0.45

[ab]Means within the same row with different superscripts are significantly different ($P < 0.10$).

[1]Backgrounding period diets are defined as BS = Oat, annual ryegrass and crimson clover baleage with 1% of animal body weight per day of dried distillers grains; HS = Bermudagrass hay with 1% of animal body weight per day of dried distillers grains; GS = Crabgrass/signalgrass grazing with 1% of animal body weight per day of dried distillers grains; GO = Crabgrass/signalgrass grazing without supplemental feed.

[2]Weaning samples were taken at weaning prior to the beginning of dietary treatments.

[3]Pre-Transport samples were taken immediately before calves were loaded for transportation from Shorter, AL to Montezuma, KS

[4]Post-Transport samples were taken immediately after arrival at the feedyard in Montezuma, KS without rest, feed, or water.

[5]24 h Rest samples were taken after animals were allowed to rest with access to hay and water for 24 h after arrival. [5]D 7 Recovery is the percentage of the Pre-Transport Body Weight recovered by d 7 on feed.

[6]Samples collected after stunning and prior to the first pathogen intervention step in the processing facility.

Chapter IV: Growth performance, carcass characteristics, pathogen shedding, and hematology of weaned calves fed cool-season baleage and hay based backgrounding diets then transported to a southern plains feedyard

INTRODUCTION

The beef cattle industry in the southeastern U.S. is predominately a cow-calf system, with more than 4 million beef cows in Alabama, Mississippi, Georgia, Florida, Tennessee, North Carolina and South Carolina, or approximately 12.8% of the total U.S. cowherd (USDA-NASS, 2017). The vast majority of the calves born in this region are eventually transported to one of the major feeding regions of the U.S. to be finished and harvested. Transportation is stressful to the animal, especially when coupled with other stressors such as weaning, castration, commingling with new animals, and nutritional change during the same period. The compounding effect of these stressors on the animal can have negative impacts on performance and health as they enter the feedyard (Carroll et al., 2007).

A widely accepted management strategy for cow-calf producers to reduce the risk of bovine respiratory disease and add value to their calf crop is to background or precondition the calf prior to shipping (Wilson et al., 2017). This backgrounding process typically includes weaning, vaccination against respiratory tract viruses and bacteria, and nutritional management aimed at supporting cost-efficient, moderate growth to prepare calves to be fed in a feedyard environment.

For producers interested in backgrounding fall-born calves in the southeastern U.S., nutritional management during this period can be challenging with limited access to high quality forage options during the summer months. Typical dry-lot backgrounding diets in the southeast

have been based around dry hay supplemented with concentrate feeds. Growing interest in baled grass silage, commonly referred to as "baleage", as a forage preservation method is providing new opportunities for producers to conserve forages at optimum quantity and forage quality (Hancock et al., 2019). This has become increasingly popular in the Southeast, as it allows forage producers to use conventional forage harvesting equipment to cut, condition, and bale forage at 40 to 60% moisture, before it is wrapped in plastic in a specialized bale-wrapper, as compared to conventional silage that requires very specialized harvest equipment and storage facilities that are not common in beef cattle operations in the south (Ball et al., 2015). Forte et. al. (2018) demonstrated that ryegrass baleage supplemented with concentrate feed can be comparable to bermudagrass hay and corn silage as an effective option to fill this gap in forage quality. Because of this ability to harvest forages at peak forage quality, it is possible to conserve forages that have sufficient protein and energy to support adequate gains for growing beef cattle. No research has been conducted to determine the feasibility of using cool-season baleage as a sole source of nutrition in the backgrounding stage.

Supplementing forage-based diets with commodity-based feedstuffs is a common practice to increase rate of gain in growing cattle to meet performance goals in the backgrounding period (Moore et al., 1999). Co-products feeds, such as dried distiller's grains with solubles (DDGS), have historically been attractive options as feed ingredients due to their relatively low cost (Rankins and Prevatt, 2013), these co-product feeds require the on-farm storage and handling capacity to receive large volumes of feed at a time. In Alabama, the average herd size of beef cattle farms is 35.9 cows (USDA-NASS, 2017) and many of these small farms do not have the resources necessary to purchase feedstuffs in this volume nor do they have the need for this volume of feed to background a small number of calves. Purchasing complete feeds

in smaller volumes from local farm stores is a viable option for many of these producers. There is interest in objectively understanding how some of these common complete feeds compare to more standard co-product feeds that have been heavily researched, such as DDGS.

While there is published literature describing the positive attributes of backgrounding on the transition of beef calves into the stocker or feedyard phase, this work largely focuses on nutritional strategies used in the Midwestern U.S. for the post-weaning calf receiving period, backgrounding, and stocker calf management (Duff and Gaylean, 2007; Cox-O'Neill et al., 2017). Nutritional management practices of beef producers in the Southeast U.S. may influence animal performance, transition, and success in the feedyard phase. The objective of this study was to evaluate the effect of backgrounding diet on growth during the preconditioning period, and subsequent influence on transport stress, transition to the feedyard, and performance through animal harvest.

MATERIALS AND METHODS

All procedures for the study were approved by the Auburn University Institutional Animal Care and Use Committee for the use of live vertebrate animals in experiments (PRN 2018-3320).

Animals and Backgrounding Period

Four diets were selected and designed to reflect backgrounding management systems and feeding practices commonly used by beef producers and potential dietary options using cool-season baleage in the Southeast U.S. region (Table 10). Backgrounding diets were: 1) *ab libitum* bermudagrass hay and 1% of body weight (BW) of dried distiller's grains with solubles (DDGS) fed daily (HD), 2) *ad libitum* cool-season annual baleage [oat (*Avena sativa*), annual ryegrass

(*Lolium multiflorum*) and crimson clover (*Trifolium incarnatum*)] and 1% of body BW DDGS

fed daily (BD), 3) *ad libitum* cool-season annual baleage and 1% of BW of a commercially

available complete beef cattle grower feed (CPC Developer, Alabama Farmer's Cooperative,

Decatur, AL) or 4) *ad libitum* cool-season annual baleage with no supplemental feed (BO).

Conserved forages were fed in open-style metal hay rings, and feed supplements were fed in

concrete bunks daily. Supplement amounts (kg/hd/d) were adjusted to achieve 1% BW after

cattle weighing events which occurred on d 0 and 30 of the 60 d backgrounding trial. All Cattle

had ad libitum access to water and mineral (Wind and Rain® All Season 7 Complete, Purina®,

Shoreview, MN). Cattle were sorted into pens of 10 head with 3 pens assigned to each dietary

treatment.

One hundred nineteen Hereford- and Angus-sired steers (n = 79, 266 ± 34 kg BW) and

heifers (n = 40, 237 ± 26 kg BW) were selected from the resident herd of the E.V. Smith

Research Center (Shorter, AL) and weaned on June 26, 2019. At weaning calves were vaccinated

with Bovi-Shield Gold (Zoetis Animal Health, Parisippany, New Jersey). Calves were housed in

drylots overnight with *ad libitum* access to water and hay before being weighed, blood being

drawn for hematology, rectal swabs collected for pathogen cultures, and assigned to treatments

groups on June 27, 2019. Twenty (n = 20) steers and ten (n = 10) heifers were assigned to HD,

BD, and BC groups. Nineteen (n = 19) steers and ten (n =10) heifers were assigned to BO pens.

Heifers and steers were mixed in pens. HD, BD, and BC diets had 2 pens with 7 steers and 3

heifers and 1 pen with 6 steers and 4 heifers. BO diet had 2 pens with 6 steers and 4 heifers and 1

pen with 7 steers and 2 heifers. Steers and heifers were assigned to dietary treatment groups such

that average steer and heifer body weights across treatments were within 1 standard deviation of

the overall sex mean body weight at weaning.

Backgrounding Management and Animal Performance Measurements

Cool-season baleage was harvested from a single cutting of the mixture when oats reached the boot-to-early dough stage on April 9th, 2019 and allowed to wilt for 24-h to achieve a moisture level of 40 to 60% prior to baling and wrapping. Moisture range of baleage prior to baling was determined using a microwave test (Steevens et al., 1993). Baleage was wrapped using an in-line wrapper with six layers of polyethylene plastic with a 50% overlap and stored until the time of feeding. Tifton 85 bermudagrass was harvested in two lots. The first lot was harvested September 21st, 2018 (BH-1) and was utilized until d 30 of the backgrounding trial. The second lot was harvested June 5th, 2019 (BH-2) and was utilized from d 30 until calves For each diet treatment that included conserved forage, samples were collected from each forage lot utilized for the study (Mullenix and Johnson, 2018), and analyzed for nutritive value. Bales were replaced every 5 d for pens fed baleage and 7 d for pens fed bermudagrass hay.

Following processing on June 27, 2019, calves were penned in their treatment groups and began a 12 d acclimation period on their respective dietary treatments before the 60-d backgrounding trial began. An initial test body weight was collected in the morning for calves at the beginning of the study on July 8, 2018. Calves were weighed on August 7, 2019, the mid-point of the 60-d background trial, and at the end of the backgrounding phase on September 6, 2019. At this time, calves were re-vaccinated with Bovi-Shield Gold One Shot (Zoetis Animal Health, Parisippany, New Jersey). After 30 d on feed, 1 steer was removed from the study due to sickness and its data removed from further analysis.

Transportation and Feedyard Management

Calves remained on their respective diets until September 24, 2019, when they were transported to a feedyard in southwest KS to be fed until harvest. On the morning of September 24, 2019, calves were individually weighed, rectal swabs were collected for pathogen detection, and blood was drawn for hematological analysis prior to transportation to the feedyard. One steer was identified as exhibiting signs of respiratory disease, and was removed from the study at this time, before samples and weights were collected. Each pen of calves was randomly assigned to one of two trucks. Calves were loaded onto trucks starting at 4 p.m. central standard time and transported approximately 1100 miles directly to the feedyard without being unloaded during the transport. Calves arrived at the feedyard at approximately 7 a.m. on the morning of September 25, 2019.

Upon arrival, calves were immediately unloaded into a holding pen with no access to feed or water. At this time, calves were visually appraised for any signs of lameness, sickness, or distress by the research team and feedyard staff. Once deemed healthy enough to continue, calves were then weighed, rectal swabs were collected for pathogen detection, and blood was drawn for hematological analysis. After processing, calves were placed in two pens, remaining in their groups by truck, and allowed to rest for 24 h with *ab libitum* access to water and hay.

After 24 h rest, calves were again weighed, rectal swabs were collected for pathogen detection, blood was drawn for hematological analysis, and typical processing at feedyard entry occurred. Feedyard entry processing included calves being: dewormed with an injectable moxidectin (Cydectin, Bayer Healthcare, LLC, Shawnee Mission, Kansas) and an oral drench oxfendazole (Synanthic, Boehringer Ingelheim Vetmedica, Inc., St. Joseph, Missouri), vaccinated for Infectious Bovine Rhinotracheitis (Pyramid 3, Boehringer Ingelheim Vetmedica, Inc., St. Joseph, Missouri), implanted with a growth promoting hormone implant (Component

TE-IS with Tylan, Elanco Animal Health, Greenfield, Indiana), prophylactically treated with tilmicosin (Micotil 300, Elanco Animal Health, Greenfield, Indiana), and tagged with a feedyard ear tag. Calves were then moved to their feeding pen, where all 117 calves were fed together until harvest.

Once moved to their feeding pen, the transition from hay to full feed began. Calves were started on a high fiber ration and gradually moved up to a finishing ration over 28 d. The final finishing ration consisted predominately of steam-flaked corn, dried distiller's grains with solubles, and alfalfa hay with a balanced mineral supplement, tylosin phosphate (Tylan 100, Elanco Animal Health, Greenfield, Indiana), and monensin (Rumensin, Elanco Animal Health, Greenfield, Indiana) included. For the final 30 d, ractopamine hydrochloride (Optaflexx, Elanco Animal Health, Greenfield, Indiana) was included in the ration.

To measure performance in the feedyard, cattle were gathered and weighed after 7d, 40 d, and 123 d on feed. Average daily gains were calculated for each period. Due to facility limitations at the feedyard and to minimize stress on the finished cattle, final weights were not individually gathered, however the entire group was weighed prior to being transported to the processing facility. Final weights were estimated based on the actual individual hot carcass weights of the animals and the dressing percentage of the entire group. Therefore, final weights, overall average daily gains, and average daily gain in the final 89 d are estimates derived from this calculation.

Cattle Harvest

After 212 d on feed, calves were transported to a commercial beef processing facility in the area and harvested in a single group. Radio frequency ID tags on the calves were scanned in

the facility to track individual animal data, and visual eartags were also recorded for redundancy. Hot carcass weights (HCW) were collected on each animal prior to carcass chilling. After chilling for ~36 h, carcasses were ribbed between the 12th and 13th rib. Ribeye area, backfat thickness, marbling score, calculated yield grade (CYG), USDA Yield Grade, and USDA Quality Grade was recorded for each animal by plant and USDA-AMS personnel using a camera grading system.

Blood Collection

To understand if there was an effect on the immune system and its response to transportation stress due to dietary treatment in the backgrounding phase, blood was collected via jugular venipuncture at weaning, prior to transportation to the feedyard, immediately post-transportation to the feedyard, and after 24 h rest following transportation to the feedyard. Blood was collected into 4.5 mL evacuated tubes containing ethylene diamine tetra-acetic acid (EDTA) (Vacutainer: Becton, Dickinson and Company, Franklin Lakes, NJ) for determination of complete blood count (CBC) using an automated hemocyotometer (Procyte Dx Hematology Analyzer; IDEXX Laboratories, Inc., Westbrook, ME) immediately after collection.

Pathogen Shedding

To understand the effects of background diet on fecal shedding of *Salmonella spp.* (SAL) and *Escherichia coli* O157:H7 (O157), two fecal swabs were taken rectally on each animal to collect feces for pathogen detection at weaning, prior to transportation to the feedyard, immediately post-transportation to the feedyard, and after 24 h rest following transportation to the feedyard. An additional sampling period was planned for the harvest date, but was cancelled due to limitations imposed by the harvest facility at the height of the COVID-19 pandemic.

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Weaning were transported back to the microbiology labs in Upchurch Hall at Auburn University in Auburn, AL for processing, and all other samples were processed at the USDA-ARS Livestock Issues Research Unit in Lubbock, TX. At both locations, the same protocol was followed.

For *SAL* detection, one rectal swab placed in 9 mL of Tetrathionate (TT) Broth with iodine supplement and incubated at 37 °C for 20 to 24 h. A 10 µL loop of the incubated broth was transferred onto Xylose Lysine Tergitol-4 (XLT-4) and incubated at 37 °C for 20 to 24 h. Following incubation, phenotypical *SAL* colonies were noted and a phenotypic colony was streaked on a Triple Sugar Iron (TSI) slant to confirm the presence of *SAL*. 1 mL of TT broth sample was transferred to 9 mL Rappaport Vassiliadis (RV) broth enrichment and incubated at 42 °C for 20 to 24 h. Any samples that were found to be negative following the TT broth enrichment and XLT-4 plating were then streak plated out of RV broth enrichment on XLT-4 and incubated at 37 °C for 20 to 24 h. Again, any phenotypical *SAL* colonies were noted and a phenotypic colony was streaked on a TSI slant to confirm the presence of *SAL*.

For *Escherichia coli* detection, the other fecal swab was placed in 9 mL of buffered peptone water (BPW) and incubated at 37 °C for 20 to 24 h. After incubation, A 10µL loop of the incubated broth was transferred onto chromogenic selective agar for *O157* (BD BBL CHROMagar O157) and incubated at 37 °C for 20 to 24 h. Plates that exhibited mauve colonies were considered positive and a single mauve colony was restreaked on to MacConkey Agar with Sorbitol and incubated at 37 °C for 20 to 24 h to isolate colonies and confirm the presence of *O157*. Additionally, 1 mL of the BPW was also placed in 9 mL of tryptic soy broth (TSB) and incubated 37 °C for 20 to 24 h to enrich the sample. All samples that were deemed negative from the first streak plates were then streak plated out of the corresponding TSB sample onto

CHROMagar O157 and incubated at 37 °C for 20 to 24 h. Again, any plates that showed mauve colonies were considered positive and a single mauve colony was restreaked on to MacConkey Agar with Sorbitol and incubated at 37 °C for 20 to 24 h to isolate colonies and confirm the presence of *O157*.

Statistical Analysis

Dietary treatments were arranged in a completely randomized design. Pen during the backgrounding phase as the experimental unit for all variables and dietary treatment was the fixed effect. Data were analyzed using GLIMMIX feature in SAS 9.4 (SAS Institute, Inc., Cary, NC). Continuous variables were subjected to analysis of variance using the least squared means syntax for Gaussian distributions with an R-side covariance structure with repeated measures. These continuous variables included body weight (BW), average daily gain (ADG), hot carcass weight (HCW), *longissimus dorsi* cross sectional area (REA), marbling score (MARB), backfat thickess (BF), calculated USDA Yield Grade (CYG), and all hematological parameters. Microbiological data, percentage of carcass that reached USDA Prime or Choice and percentage of carcasses that were USDA Yield Grades 1-3 were coded into a binomial variables (1 = positive, 0 = negative) by individual animal. This binomial data was analyzed similarly using GLIMMIX feature of SAS 9.4 (SAS Institute, Inc, Cary, NC) for analysis of variance for binominal distributions and LOGIT link function with an R-side covariance structure. For each variable diet by time interactions were analyzed. If there was no significant interaction, then diet within time period was reported. Least square means were separated using the PDIFF function and standard of the collective means are reported. Alpha was 0.10.

RESULTS AND DISCUSSION

Backgrounding Period

Diet and time both had a significant effect on BW ($P < 0.01$) and ADG ($P < 0.10$) during the backgrounding period. Additionally, there were significant interactions between these two terms for both BW ($P = 0.07$) and ADG ($P = 0.03$). These interactions are described in Table 19, as well as differences in overall ADG for 60 d backgrounding period by diet ($P < 0.01$).

Body weight (BW) was not different among dietary treatments at d 0 ($P < 0.10$). ADG differed between all diets ($P < 0.10$) from d 0 through d 30, with BD calves having the greatest ADG, followed by BC, then HD and finally BO. At d 30, all dietary groups increased BW compared to d 0 ($P < 0.10$), but differences in BW were observed between diet at that time. BD and BC calves were not different than one another ($P > 0.10$), but were heavier than BO calves ($P < 0.10$). HD calves were not different from all other diets on d 30 ($P > 0.10$). From d 30 through d 60, all diet groups had reduced ADG compared to the first half of the backgrounding period ($P < 0.10$). During the second half of the backgrounding period, BD and BC calves had the greatest ADG ($P < 0.10$), with HD calves having reduced performance and BO calves being lower than all groups. When looking at BW, HD, BD, and BC groups all had heavier BW on d 60 than d 30 ($P < 0.10$), but BO calves did not have a significant change in BW from d 30 to d 60 ($P > 0.10$). HD, BD, and BC groups were not different from one another ($P > 0.10$) and were significantly heavier than BO calves ($P < 0.10$) on d 60. When analyzing the overall ADG of the 60 d backgrounding period, BD and BC were not different from one another ($P > 0.10$), but were greater than HD and BO groups ($P < 0.10$). BO calves had the lowest ADG ($P < 0.10$) and HD calves were different from all other treatments ($P < 0.10$).

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Achieving gains of 0.68 kg/d or greater is a common goal for most backgrounding or stocker systems (Ball et al., 2015). In this study, all diets containing supplementation exceeded this performance threshold for the first 30 d of backgrounding and over the entire 60 d period. This is important, as it demonstrates that both DDGS and CPC can perform in a sufficient manner to support gains when using cool-season baleage as the base of the diet. Further, even relatively poor to average quality hay (Table 17) can function as an effective roughage source for backgrounding calves, when supplemented at 1% of BW with a high protein, high energy supplemental feed such as DDGS (Table 17.). Using cool-season baleage without supplementation was ineffective as it was utilized in this study. This is likely due to two factors: reduced dry matter intake by calves and insufficient nutrient intake for growth. With a crude protein (CP) of 9.19% and total digestible nutrient (TDN) percentage of 62.7%, this baleage had adequate CP and TDN to meet the 0.68 kg/d threshold if calves were eating 2.9% of BW in DM daily (NRC, 2016; Mullenix et al., 2021). However, this feed had a TDN:CP of 6.8, indicating that the forage was possibly N deficit in relation to its available energy, potentially limiting intake (Moore et al., 1999). Other environmental factors might have compounded this issue and further reduced intake. New bales of baleage were placed in pens every 5 d in an attempt to balance baleage use and aerobic and heat related spoilage of this high moisture feed. Panhans et al. (2020) observed that beef cows wasted 2.5 to 3 times as much baleage compared to dry hay due to a lack of feeding pressure and visible spoilage when feeding cows in the winter in Alabama for 5 d periods. Increased heat in the summer months that this study was conducted during had an increased negative effect on feeding times and spoilage of baleage. Only providing enough baleage to meet the intake needs of animals for 24 to 48 h is a more effective method to reduce waste and spoilage (Dillard et a., 2018). With 10 calves per pen, BO groups would have

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an estimated daily DM intake of ~66 kg or 48 h intake of ~132 kg, compared to an average bale

DM weight of 319 kg. In a 5 d feeding period, calves should have had little baleage waste. Intake

was not directly measured, nor was baleage refusal, but significant waste was seen. With forage

quality of this baleage being just high enough to meet performance expectations with expected

DM intake, this potentially reduction in total forage intake would have reduced total intake of

protein and energy such that cattle performed poorly. Performance and baleage use from the

previous year using baleage with supplemental DDGS did not indicate that there would be any

problem with intake of baleage by growing calves. Additionally, performance of calves fed

baleage plus supplemental feed in this study was more than adequate and slightly greater than

expected, with the same baleage being fed as a roughage component of the diet.

Transportation, Feedyard Performance and Carcass Merit

Calf performance responses following transport to southwest Kansas are presented in

Table 20. Diet and date both had a significant effect on BW ($P < 0.01$), but the interaction of diet

by date was not significant ($P = 0.99$). Dietary differences within weigh date are reported in

Table 20. At each of the three weigh dates surrounding transportation, HD, BD, and BC groups

were not different from one another ($P > 0.10$), but were heavier than BO calves ($P < 0.10$).

When analyzing BW shrink, dietary differences within weigh date are reported in Table

20. Immediately after transportation with no rest, BO calves had the greatest shrink value

compared to all other treatments ($P < 0.01$) with none the other treatments being different ($P >$

0.10). BO calves had the greatest BW shrink compared to all other groups after 24 h rest ($P <$

0.10). BC calves had greater shrink compare to HD calves ($P < 0.10$), but BD calves were not

different from HD and BC calves ($P > 0.10$) after 24 h rest. After 7 d on feed, BO calves had

recovered the lowest percentage of their pre-transport BW compared to all other treatment groups ($P < 0.10$), which did not differ from one another ($P > 0.10$). Shrink is not only the loss of gut fill over time, but also the loss of body tissue and fluid (Coffey et al., 2001). By allowing animals to rest 24 with free choice access to water and hay, shrink at that point could indicate differences in body tissue loss during shrink and/or adaptation to the feedyard environment. Shrink values reported for HD, BD, and BC calves are similar to those reported in the literature, but BO calves were elevated by comparison (González et al., 2012). With the greatest shrink immediately after transportation and rest and lowest BW recovery after 7 d on feed, BO calves performed the least favorably during transportation and in early feedyard adaptation, in terms of growth performance.

Table 21 highlights the performance of the calves during the feeding period after arrival at the feedyard and the carcass data from the calves after harvest. Diet and weigh date both affected BW ($P < 0.10$), but there was no diet by weigh date interaction effect ($P = 0.97$). At no point during the feeding period were there differences in BW between any of the groups that received supplemental feed during the backgrounding period ($P > 0.10$). Similar to what was observed at the end of the backgrounding period and throughout transportation, BO calves had lighter BW than all supplemented groups at d 0, ($P < 0.01$), d 7 ($P < 0.01$) , d 40 ($P = 0.02$), and d 123 ($P = 0.07$). Final estimated body weights at slaughter were not different ($P > 0.10$).

ADG was calculated for each period of time between weigh dates to observe the changes in growth by calves during shorter periods of time. All mean ADGs were analyzed together to determine if a period by diet interaction occurred. This interaction did not have a significant effect ($P = 0.26$). Data was re-analyzed to determine differences by diet at each growth period. No differences were detected in ADG during any time period of the feeding phase ($P > 0.10$).

Similar to ADG throughout the feeding period and final BW, no differences were observed for hot carcass weight (HCW, $P = 0.44$), ribeye area (REA, $P = 0.93$), marbling score ($P = 0.13$), calculated USDA Yield Grade (CYG, $P = 0.28$), percentage of cattle that grade USDA Yield Grade 1-3 ($P = 0.36$) and backfat thickness ($P = 0.56$). Only the percentage of carcasses that graded USDA Choice and Prime were different ($P = 0.02$). Fewer BO calves reached USDA Choice or Prime compared to all other dietary treatments ($P < 0.10$), however BD, BC, and HD groups were not different from one another ($P > 0.10$).

Many published studies would indicate that dietary differences during the backgrounding phase have a negligible difference on subsequent feedyard performance and carcass characteristics (Loken, et al, 2009; Kumar et al., 2012; Gadberry et al., 2012; Lancaster et al., 2014). Differences in HCW, REA, marbling score, and percent Choice based on backgrounding diets of corn residue grazing, cover crop grazing, or drylot backgrounding methods, were reported by Cox O'Neill et al. (2017). However, this study utilized a much larger number of animals and detected differences in variable with smaller differences in treatment means that seen in this study. Data from this study would tend to agree with most of the literature that diet during the backgrounding phase has a minute impact on feedyard performance, at best. However, the limitations in animal number, animal uniformity, and feeding management constraints of BO groups makes definitive conclusions difficult.

Complete Blood Counts

Red blood cell count (RBC), hemoglobin concentration (HGB), and hematocrit percentage (HCT) data from blood collections at weaning and around the transportation event are presented in Table 14. RBC differed by diet ($P < 0.01$), sampling date ($P < 0.01$), and there was

a significant diet by date interaction ($P = 0.02$). This interaction is shown in Table 14.

Interestingly, prior to any treatments after being assigned to treatment groups at weaning, BO calves had lower RBC than all other groups ($P < 0.10$), with all other groups were not different that one another ($P > 0.10$). Prior to the transportation event, HD and BD calves' RBC were not different from one another ($P > 0.10$), but were greater than BC ($P < 0.10$). At the pre-transportation bleeding, BO calves had the lowest RBC ($P < 0.10$). Surrounding the transportation event, changes in RBC varied by diet. No change in RBC over time was detected in HD and BD calves ($P > 0.10$). RBC in BC calves increased from pre-transportation to post-transportation ($P < 0.10$), but RBC after 24 h rest was not different than either previous time point ($P > 0.10$). BO calves had lower RBC at all time points compared to all other diets within the same time point ($P < 0.10$). RBC increased in BO calves from pre-transport to the bleeding event after 24 h of rest ($P < 0.10$), but RBC immediately after transportation was not different than pre-transportation or 24 h rested RBC ($P > 0.10$). Due to an error with the hemocytometer, 41 of 119 HGB reading were lost, so HGB at weaning was not analyzed. There was no diet by time interaction for HGB ($P = 0.44$) and only the effect of diet within time point is reported in Table 14. The same trend existed pre- and post-transportation: BD calves had the greatest HGB ($P < 0.10$), with HD and BC calves being lower ($P < 0.10$) and not different than one another ($P > 0.10$), while BO calves had the lowest HGB ($P < 0.10$). After 24 h of rest, there were no differences between HD, BD, and BC calves ($P > 0.10$). A diet by sampling date interaction was significant for HCT ($P < 0.01$) and is reported in Table 22. Similar to RBC, BO calves had significantly lower HCT at weaning compared to other diets ($P < 0.10$), while other diets were not different from one another ($P > 0.10$). HD calves did not have different HCT at any time point ($P > 0.10$). No diet saw a change in HCT from pre-transportation to post-transportaion ($P >$

0.10). BC and BO calves increased from post-transportation to the sampling after 24 h rest ($P <$ 0.10). BD calves did not have differences at any of the time points surrounding transportation ($P > 0.10$). BO calves had lower HCT at each time point compared to all other treatments ($P < 0.10$). While differences were observed for blood count responses due to nutritional strategy during the backgrounding phase, all reported averages fell within or just above reference ranges found in the literature for beef cattle (George et al., 2010; Roland et al., 2014). Differences seen at weaning were surprising. Histograms were created using the PROC SGPLOT function of SAS 9.4 (SAS Institute, INC, Cary, NC) to confirm normal distribution of samples for each diet and each variable. Differences for RBC were small and may not be biologically significant. Reduction in RBC, HGB, and HCT seen in BO calves could be the result of different physiological issues. These differences between BO calves and others could be ascribed to blood-loss (Merdana et al., 2020), however that can be ruled out in this study. Reduction in RBC, HGB, and HCT, like what is seen in BO calves compared to others, could indicate anemia (Roland et al., 2014), however unless it is anemia related to poor performance and apparent suboptimal nutrition, other causes of anemia seen unlikely. Hematocrit can be used as an indicator of hydration status, with increased HCT shown when water is withheld from cattle (Schaefer et al., 1990). Research in the area of dietary impacts on hydration around transportation is limited. In this study, GO calves had consistently lower HCT, which could indicate a better hydration status for calves in that treatment group relative to supplemented groups. Overall, this data from this study agrees with other studies that transportation can cause an increase in HCT (Ali-Gholi et al., 2007; Bernardini et al., 2012).

Increased white blood cell (WBC), neutrophil concentration (NEU), and decreased lymphocyte concentration (LYM) are all commonly observed changes in calves in response to

stress (Earley et al., 2017). These parameters serve as an indicator of immune response with WBC representing total count of all leukocyte subpopulations (Roland et al., 2014), neutrophils being an important component of the innate immune system, and lymphocytes being a key component of the adaptive immune system (Carroll et al., 2007). Differences in WBC, NEU, LYM, and neutrophil-to-lymphocyte ratio (N:L) for each dietary treatment are presented in Table 23. Diet ($P = 0.02$) and time ($P < 0.01$) had a significant effect on WBC as did the interaction of the two terms ($P = 0.08$). No differences were detected between groups at weaning ($P > 0.10$) for WBC. HD and BC calves did not have differences in WBC between time points ($P > 0.10$). BD and BO calves' WBC increased from pre-transportation to post-transportation ($P < 0.10$) and decreased from post-transportation to 24 h of rest ($P < 0.10$), but pre-transportation WBC were not different than those counts after 24 h rest ($P > 0.10$). Pre-transportation and after 24 h rest, BO calves had the lowest WBC compared to all other groups ($P < 0.10$), but HD, BD, and BC groups were not different from one another ($P > 0.10$) at both of these time points. Post-transportation, WBC did not differ between HD, BD, and BC calves ($P > 0.10$), however BO calves had lower WBC than HD and BD groups ($P < 0.10$) and were not different from BC calves ($P > 0.10$).

Diet ($P = 0.03$) and time ($P < 0.01$) had a significant effect on NEU, as did the interaction of diet and time ($P = 0.08$). No differences were detected at weaning ($P < 0.10$) in NEU. All diets had an increase in NEU from pre-transportation to immediately post-transportation ($P < 0.10$) and a decrease from immediately post-transportation to after 24 h of rest ($P < 0.10$). However, no diet was different between pre-transportation NEU and NEU after 24 h rest ($P > 0.10$). After 24 h rest, BO calves had the lowest NEU compared to all other groups ($P < 0.10$), however HD, BD, and BC calves were not different than one another ($P > 0.10$). Post-

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transportation BD calves had greater NEU compared to BO calves ($P < 0.10$), but BD and HD calves were not different than any of the diets at this time point ($P > 0.10$). Date had a significant effect on LYM ($P < 0.01$), however diet was not significant ($P = 0.11$) nor was the diet by date interaction ($P = 0.85$). Further, when analyzing diet effects on LYM within each date, there were no significant differences in any diet at any time ($P \geq 0.31$). While time was significant for N:L ($P < 0.01$), the interaction between time and diet was insignificant ($P = 0.44$). As such, the differences between diets within time points are reported in Table 23. No differences in N:L were observed at weaning or immediately post-transportation ($P > 0.10$). Prior to transportation, BO calves had the lowest N:L compared to all other groups ($P < 0.10$), however HD, BD, and BC calves were not different from one another ($P > 0.10$). After 24 h rest, BD calves had the greatest N:L followed by BC calves and BO calves ($P < 0.10$), with HD calves not being different than BD or BC calves ($P > 0.10$).

While differences were observed between treatments, all reported averages fell within or just above reference ranges found in the literature for beef cattle (George et al., 2010; Roland et al., 2014). Differences seen in NEU and N:L dietary treatment groups indicate that cattle fed these diets had differing responses to the stress of transportation. The increase in NEU immediate post transportation seen in this study agrees with what has been previously reported in the literature (Swanson et al., 2001; Sporer et al., 2007). Hulbert et al. (2011) observed a similar response to transportation, where N:L increases after transportation then returns to pre-transportation baseline over time. As neutrophils are a primary component of the innate immune system and lymphocytes a primary component of the acquired immune system (Carroll et al., 2007), this increase in NEU would be indicative of animals responding to stress and preparing for a challenge to their homeostasis. While there were no differences between diets for LYM,

however differences in NEU would indicate some difference in the innate immune system of animals. BO calves being lowest at each time point might indicate a less functional innate immune system. It might be possible to explain a reduction in WBC and NEU in BO calves similarly to the reduction in HCT, as these animals might be better hydrated and have a greater percentage of blood volume as plasma and a lesser percentage of the blood volume as the cellular components. However, there were no differences in LYM between diets. This either means that the prior theory of increased hydration and decreased concentration of WBC is true and LYM production is actually increased in BO calves but offset by the increase blood plasma concentration or that NEU production for these calves was reduced. Regardless, there were no differences in number of calves treated for respiratory disease by feedyard or death-loss between dietary groups ($P > 0.10$, not reported in tables). Further investigation would be needed to draw a definitive conclusion. Two calves were treated for bloat in the BO group with no others in the study, however this when analyzed this was not significantly different from other groups ($P = 0.17$, not reported in tables).

Pathogen Shedding

Fecal shedding of SAL and O157 was measured and the percentage of animals testing positive for each diet at weaning, prior to transportation, immediate after transportation with no rest, and after 24 h rest. Sampling was planned to occur at harvest, however due to the COVID-19 pandemic, the selected harvest facility refused to allow the research team to enter the facility to collect samples. Due to the variable and unpredictable nature of the harvest of finished cattle during that time, the potentially health risk to researchers traveling during the pandemic, and because of the added risk it posed to cattle for increased stress induced carcass defects, it was decided to not attempt to collect fecal samples of the live animals prior to transportation to the

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harvest facility. Only one (n=1) animal at one time point tested positive for SAL (after 24 h rest in the feedyard) and only four (n=4) animals, all at the pre-transportation time point, tested positive for O157. As such, there were insufficient number of positive animals to determine if there was a transportation or dietary effect on pathogen shedding in this year of production.

CONCLUSIONS

Three of the four backgrounding diet systems provided to newly weaned calves in this project supported growth through the summer months. For producers weaning fall-born calves in late spring and summer, using DDGS or a commercial available feed with bermudagrass hay or cool-season baleage can be effective in supporting growth during the backgrounding period and achieving gains greater than the targeted performance threshold of 0.68 kg/d (Ball et al., 2015). However this study failed to demonstrate that high quality cool-season baleage can be an effective diet for the backgrounding period when fed alone. As discussed early, further research is needed to determine if this is the result of poor baleage utilization and better feeding management could make it a viable option, or if baleage use should be accompanied by supplemental feed in this segment of the beef production system.

This data also suggests that diet during the backgrounding phase has greater impact on the beef production system than just the performance of that brief period. With as many as 75% of all feedyard animals that must be treated for respiratory disease being first treated within 40 d of arrival (Avra et al., 2017), improvements in adaptation and increased feed intake at feedyard entry are critical to minimizing early disease issues and reducing morbidity and mortality (Wolfger et al., 2015). In this study, backgrounding diet affected shrink and early feedyard performance. Backgrounding diet also created differences in basic hematology, although the pattern of this response is not well understood. Further research is necessary to understand how

this interaction occurs and if there are real-world applications that can made to the

backgrounding dietary management of beef calves to have positive impact on animal health,

performance, and beef system food safety.

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Table 18. Forage production and chemical composition characteristics of conserved forages, co-product supplements, and commercial complete feeds fed during a 60-d backgrounding trial for weaned beef calves.

Item	CSB[1]	BH-1	BH-2	DDGS	CPC
Moisture, % as fed	64.6	14.4	7.1	10.2	8.34
Nutrient Analysis[2]					
CP	9.2	7.9	9.9	32.7	15.4
NDF	58.2	79.7	76.8	28.2	30.8
ADF	33.8	45.0	46.4	9.5	14.2
TDN	62.7	49.4	46.9	83.8	70.2
Mean Bale Weight (kg)	901	570	570	--	--

[1]CSB = cool-season annual baleage harvested in the boot-to-early dough stage; BH-1= Tifton 85 bermudagrass hay fed during the first 30 d of backgrounding; BH-2= Tifton 85 bermudgrass hay fed during the second 30 d of the backgrounding period; DDGS = dried distillers grains with solubles; CPC= CPC Developer Feed (Alabama Farmer's Cooperative, Decatur, AL), respectively.
[2]Values reported on a % DM basis, based on analysis from the Auburn University Soil, Forage, and Water Testing Laboratory.

Table 19. Mean body weight (kg) and mean average daily gain (kg/d) of calves during a 60-d backgrounding period using conserved forage-based systems.

Body Weight, kg^2	Diet[1]					
	HD	BD	BC	BO	SEM	*P*
D 0	263.1^{ef}	262.0^f	264.2^{ef}	262.3^f		
D 30	293.7^{cd}	302.6^{bc}	300.6^{bc}	274.4^{de}	9.9	0.07
D 60	313.3^{ab}	328.1^a	328.7^a	280.2^{de}		

ADG, kg/d^2	Diet					
	HD	BD	BC	BO	SEM	*P*
D 0 to 30	1.02^c	1.35^a	1.21^b	0.38^f	0.06	0.03
D 30 to 60	0.65^e	0.85^d	0.94^{cd}	0.19^g		

ADG, kg/d	Diet					
	HD	BD	BC	BO	SEM	*P*
Overall	0.84^i	1.10^h	1.08^h	0.29^j	0.03	<0.01

^{abcdefg}Within section of the table, means without common superscripts differ ($P < 0.10$)
^{hij}Within a row, means without common superscripts differ ($P < 0.10$).
[1]Backgrounding period diets are defined as HD = Bermudagrass hay with 1% of animal body weight per day of dried distillers grains; BD = Oat, annual ryegrass and crimson clover baleage with 1% of animal body weight per day of dried distillers grains; BC = Oat, annual ryegrass and crimson clover baleage with 1% of animal body weight per day of CPC Developer feed; BO = Oat, annual ryegrass and crimson clover baleage without supplemental feed.
[2]Interaction of Diet by Time

Table 20. Calf body weight and percentage of body weight shrink loss following transport from Shorter, AL to the feedyard in Montezuma, KS.

Body Weight, kg	Diet[1]					
	HD	BD	BC	BO	SEM	*P*
Pre-Transport[2]	324.1[a]	342.3[a]	341.6[a]	287.4[b]	7.7	<0.01
Post-Transport[3]	292.3[a]	308.7[a]	305.4[a]	250.8[b]	6.9	<0.01
24 h Rest[4]	302.3[a]	315.9[a]	313.7[a]	257.0[b]	7.1	<0.01
Shrink Loss (% of Animal Body Weight)	Diet					
	HD	BD	BC	BO	SEM	*P*
%, Post-Transport	9.8[b]	9.7[b]	10.5[b]	12.8[a]	0.4	<0.01
%, 24 h Rest	6.8[c]	7.7[bc]	8.1[b]	10.6[a]	0.4	<0.01
%, D 7 Recovery[5]	96.2[a]	96.2[a]	96.6[a]	93.5[b]	0.6	<0.01

[abc]Means within the same row with different superscripts are significantly different($P < 0.10$)
[1]Backgrounding period diets are defined as HD = Bermudagrass hay with 1% of animal body weight per day of dried distillers grains; BD = Oat, annual ryegrass and crimson clover baleage with 1% of animal body weight per day of dried distillers grains; BC = Oat, annual ryegrass and crimson clover baleage with 1% of animal body weight per day of CPC Developer feed; BO = Oat, annual ryegrass and crimson clover baleage without supplemental feed.
[2]Pre-Transport observations are those taken immediately before calves were loaded for transportation from Shorter, AL to Montezuma, KS
[3]Post-Transport observations are those taken immediately after arrival at the feedyard in Montezuma, KS without rest, feed, or water.
[4]24 h Rest observations are those taken after animals were allowed to rest with access to hay and water for 24 h after arrival.
[5]D 7 Recovery is the percentage of the Pre-Transport Body Weight recovered by d 7 on feed.

Table 21. Calf feedyard performance and carcass characteristics when backgrounded using conserved forage-based systems.

Body Weight, kg	Diet[1]					
	HD	BD	BC	BO	SEM	*P*
D 0	302.3[a]	315.9[a]	313.7[a]	257.0[b]	7.1	<0.01
D 7	312.0[a]	329.1[a]	329.5[a]	269.2[b]	7.5	<0.01
D 40	374.2[a]	388.6[a]	388.2[a]	339.5[b]	9.1	0.02
D 123	517.1[a]	523.3[a]	530.1[a]	479.3[b]	12.0	0.07
Final	618.5	630.0	639.0	605.7	14.4	0.44

ADG, kg/d	Diet					
	HD	BD	BC	BO	SEM	*P*
D 0 to 7	1.39	1.89	2.24	1.74	0.22	0.12
D 7 to 40	1.86	1.82	1.80	2.07	0.12	0.43
D 40 to 123	1.72	1.62	1.71	1.69	0.07	0.72
D 123 to 212	1.14	1.20	1.22	1.27	0.06	0.13
Overall	1.49	1.49	1.53	1.64	0.04	0.13

Carcass	Diet					
	HD	BD	BC	BO	SEM	*P*
HCW, kg	400.2	407.7	413.5	392.0	9.3	0.44
REA, sq. cm[2]	99.4	99.2	97.6	98.5	2.2	0.93
Marbling[3]	450	475	488	424	17	0.13
% Choice[4]	73.1[a]	88.9[a]	88.9[a]	48.0[b]	8.0	0.02
CYG[5]	3.05	3.16	3.36	2.95	0.14	0.28
% YG 1-3[6]	84.6	77.8	81.5	96.0	7.0	0.36
Backfat, cm[7]	1.66	1.69	1.77	1.59	0.09	0.56

[abc]Means within the same row with different superscripts are significantly different ($P < 0.10$).

[1]Backgrounding period diets are defined as HD = Bermudagrass hay with 1% of animal body weight per day of dried distillers grains; BD = Oat, annual ryegrass and crimson clover baleage with 1% of animal body weight per day of dried distillers grains; BC = Oat, annual ryegrass and crimson clover baleage with 1% of animal body weight per day of CPC Developer feed; BO = Oat, annual ryegrass and crimson clover baleage without supplemental feed.

[2]REA is the area of the *L. dorsi* in square centimeters at the break between the 12th and 13th rib of the carcass.

[3]Marbling Score 300-399= Slight 400-499= Small 500-599=Modest degree of marbling in the *L. dorsi* when observed at the break between the 12th and 13th rib.

[4]Percentage of carcasses that were graded USDA Choice or USDA Prime

[5]The unrounded calculated USDA Yield Grade

[6]Percentage of carcasses that were graded USDA Yield Grade 1, 2, or 3.

[7]Thickness of the subcutaneous fat at the break between the 12th and 13th rib, measured in centimeters

Table 22. Red blood cell count, hemoglobin concentration, and hematocrit percentage following transportation from Shorter, AL to Montezuma, KS of calves fed different backgrounding diets.

Red Blood Cells Million cells/µL	Diet[1]					
	HD	BD	BC	BO	SEM	*P*
Weaning[2]	10.57^{ab}	10.63^{ab}	10.68^{a}	10.09^{cde}		
Pre-Transport[3]	10.01^{de}	10.19^{bcd}	9.46^{f}	8.17^{h}	0.27	0.02
Post-Transport[4]	10.27^{abcd}	10.53^{abc}	9.92^{de}	8.53^{gh}		
24 h Rest[5]	10.38^{abcd}	10.21^{bcd}	9.72^{ef}	8.86^{g}		
Hemaglobin Grams/dL	Diet					
	HD	BD	BC	BO	SEM	*P*
Weaning	-	-	-	-	-	-
Pre-Transport	12.97^{j}	13.66^{i}	12.93^{j}	10.54^{k}	0.24	<0.01
Post-Transport	13.32^{j}	14.14^{i}	13.48^{j}	10.93^{k}	0.20	<0.01
24 h Rest	13.25^{i}	13.55^{i}	13.38^{i}	11.49^{j}	0.30	<0.01
Hematocrit Percentage (%)	Diet					
	HD	BD	BC	BO	SEM	*P*
Weaning	40.42^{cde}	41.36^{bcd}	41.06^{cd}	38.65^{e}		
Pre-Transport	40.06^{cde}	43.14^{ab}	39.61^{de}	31.24^{g}	0.87	<0.01
Post-Transport	41.48^{bcd}	44.60^{a}	40.71^{cd}	33.23^{g}		
24 h Rest	41.47^{bcd}	43.36^{ab}	41.90^{bc}	35.62^{f}		

^{abcdefgh}Means within the same section of the table with different superscripts are significantly different (*P* < 0.10).

^{ijk}Means within the same row with different superscripts are significantly different (*P* < 0.10).

[1]Backgrounding period diets are defined as HD = Bermudagrass hay with 1% of animal body weight per day of dried distillers grains; BD = Oat, annual ryegrass and crimson clover baleage with 1% of animal body weight per day of dried distillers grains; BC = Oat, annual ryegrass and crimson clover baleage with 1% of animal body weight per day of CPC Developer feed; BO = Oat, annual ryegrass and crimson clover baleage without supplemental feed.

[2]Weaning observations are those taken at weaning prior to the beginning of dietary treatments.

[3]Pre-Transport observations are those taken immediately before calves were loaded for transportation from Shorter, AL to Montezuma, KS

[4]Post-Transport observations are those taken immediately after arrival at the feedyard in Montezuma, KS without rest, feed, or water.

[5]24 h Rest observations are those taken after animals were allowed to rest with access to hay and water for 24 h after arrival. [5]D 7 Recovery is the percentage of the Pre-Transport Body Weight recovered by d 7 on feed.

Table 23. White blood cell, neutrophil, and lymphocyte counts and neutrophil to lymphocyte ratio following transportation from Shorter, AL to Montezuma, KS of calves fed different backgrounding diets.

White Blood Cells Thousand Cells/ µL	Diet[1]					
	HD	BD	BC	BO	SEM	*P*
Weaning[2]	11.19[cd]	10.72[de]	10.96[d]	11.51[bcd]		
Pre-Transport[3]	12.10[abc]	11.45[cd]	11.24[cd]	9.91[ef]	0.41	0.08
Post-Transport[4]	12.45[ab]	12.63[a]	11.94[abc]	11.35[cd]		
24 h Rest[5]	11.50[bcd]	10.81[de]	11.19[cd]	9.57[f]		

Neutrophils Thousand Cells/ µL	Diet					
	HD	BD	BC	BO	SEM	*P*
Weaning	3.52[c]	3.47[c]	3.40[c]	3.91[c]		
Pre-Transport	2.58[de]	2.40[de]	2.09[ef]	1.75[f]	0.16	0.08
Post-Transport	5.49[ab]	5.82[a]	5.40[ab]	5.05[b]		
24 h Rest	2.74[d]	2.75[d]	2.38[de]	1.57[f]		

Lymphocytes Thousand Cells/ µL	Diet					
	HD	BD	BC	BO	SEM	*P*
Weaning	6.56	6.21	6.54	6.51	0.25	0.74
Pre-Transport	8.12	7.66	7.67	7.30	0.29	0.32
Post-Transport	5.74	5.52	5.26	5.31	0.19	0.31
24 h Rest	7.32	6.64	7.00	6.68	0.29	0.37

Neu:Lym Ratio	Diet					
	HD	BD	BC	BO	SEM	*P*
Weaning	0.56	0.58	0.54	0.62	0.04	0.59
Pre-Transport	0.32[g]	0.32[g]	0.28[g]	0.22[h]	0.02	0.01
Post-Transport	0.99	1.08	1.06	0.99	0.07	0.69
24 h Rest	0.38[gh]	0.41[g]	0.35[h]	0.27[i]	0.03	0.02

[abcdef]Means within the same section of the table with different superscripts are significantly different ($P < 0.10$)

[ghi]Means within the same row with different superscripts are significantly different ($P < 0.10$).

[1]Backgrounding period diets are defined as HD = Bermudagrass hay with 1% of animal body weight per day of dried distillers grains; BD = Oat, annual ryegrass and crimson clover baleage with 1% of animal body weight per day of dried distillers grains; BC = Oat, annual ryegrass and crimson clover baleage with 1% of animal body weight per day of CPC Developer feed; BO = Oat, annual ryegrass and crimson clover baleage without supplemental feed.

[2]Weaning observations are those taken at weaning prior to the beginning of dietary treatments.

[3]Pre-Transport observations are those taken immediately before calves were loaded for transportation from Shorter, AL to Montezuma, KS

[4]Post-Transport observations are those taken immediately after arrival at the feedyard in Montezuma, KS without rest, feed, or water.

[5]24 h Rest observations are those taken after animals were allowed to rest with access to hay and water for 24 h after arrival. [5]D 7 Recovery is the percentage of the Pre-Transport Body Weight recovered by d 7 on feed.

Chapter V: Summary

Many variables can effect profitability in the cattle industry, especially from weaning through harvest. While genetic selection and health management in the form of vaccines and other pharmaceuticals are synonymous with managing for success post-weaning in the minds of many producers, several of these variables in the feedyard and on the rail can be influenced by management during the backgrounding phase. However, with the heavily segmented nature of the beef industry, communication of the successes and failures of cattle in the feedyard and on the rail is rarely sent back to those producers that make the genetic, health management, and nutritional decisions leading up to transportation to the feedyard. In parts of the country where processing facilities are prevalent, it is possible for cattle producers to "vertically integrate" their farms and finish their own cattle, taking control of the entire live production system. However for southern cattlemen, that is an unlikely solution on a large scale. Using a custom feedyard and retaining ownership is a much more likely scenario. For producers that are unable to gather enough cattle to fill a truckload lot (approximately 48,000 to 50,000# of similar sized cattle) this, too, is not a likely answer without some form of commingling cattle with other producers, or using programs like Alabama Pasture to Rail.

After reviewing data collected on the 2,188 calves shipped through P2R from 2016 through 2020, several things can be learned about profitability in the feedyard. First, while there is year-to-year variability, retaining ownership can be a profitable marketing strategy. In these 4 years, 3 years averaged profits greater than $89/hd with the fourth year being a breakeven. These results agree with other published literature that most years can be profitable (Wagner et al., 1991; Fausti et al., 2003; Tang et al., 2017). Second, health is key. When cattle are pulled from pens by feedyard staff and treated a single time, profitability decreases by $171.04/hd, the

incident of death-loss increases from 0.8% to 9.3%, and performance metrics are negatively impacted. Cattle that handle the stress of transportation, adapt to the feedyard environment quickly, and don't become sick are vital to success. Finally, cattle have to perform. Stepwise regressions of this data indicate that net carcass value explains more than half the variation in profitability, hot carcass weight can explain 70% of the variation in net carcass value, and average daily gain and animal body weight at shipping can explain 81% of variation in hot carcass weight. In an environment where greater than 75% of cattle grade USDA Choice or Prime, this data would indicate that selecting for and managing to produce cattle that have exceptional growth and heavy feedyard entry weights can have an impact on profitability in this phase of production. Similar data from earlier years would agree that hot carcass weight is a key driver of profitability (Gadberry et al., 2006). While genetic selection is a key component to creating cattle that can excel in this area, cattlemen can also impact this with their nutritional management decisions pre- and post-weaning.

In the southeastern U.S., fall calving is a viable option due to relatively mild fall and winter conditions and the ability to grow cool-season forages and limit winter feeding costs. This is an attractive option for many producers, as it allows them to market their calves at seasonal lows for cattle inventory and seasonal highs for cattle prices at nearly potential marketing point. Fall-born calves must be weaned in the spring or early summer. Growing high quality forages is a challenge during the summer months, with variable rainfall and high temperatures. Additionally, limited data exists in using warm-season grazing options for backgrounding feeder calves. Further, emerging interest in baleage technology presents producers with the ability to make high quality conserved forage from cool-season forages, but research into its use in backgrounding diets is limited.

The first of these two studies evaluated a traditional summer backgrounding diet (bermudagrass hay with DDGS supplementation) with three experimental diets: cool-season baleage fed with supplemental DDGS or grazing crabgrass with and without supplemental DDGS. All diets containing supplemental feed performed similarly, demonstrating that any of these three available forage resources was viable. Crabgrass grazing supported adequate gains for 28 d, but not for the full 60 d. However, it is possible that with better grazing management, crabgrass could have been sufficient alone.

The second study evaluated the same traditional diet (bermudagrass hay with DDGS supplementation) with cool-season baleage that was fed with three supplementation strategies: no supplement, DDGS, or a commercially available feed. The commercial feed was chosen as it was representative of what many small cattle producers in Alabama would have access to locally. Supplemented diets all performed adequately. Calves fed baleage only, however, struggled greatly. At no point did baleage alone support expected gains. This could be due to management and feed strategy in this experimental environment, as the baleage was of sufficient quality to support 0.68 kg/d gains with normal intake.

In both years, similar trends emerged as calves were followed into the feedyard and onto the rail. For most performance metrics, there were no statistical differences between diets by the time calves reach slaughter. This would agree with several studies in the literature, that backgrounding diet does not greatly impact feedyard performance or carcass merit (Loken, et al, 2009; Kumar et al., 2012; Gadberry et al., 2012; Lancaster et al., 2014), however a similar study in the Midwest did detect differences between dietary groups in HCW, REA, and marbling score that were similar to differences seen in the two studies described above, however those authors

used a much larger number of animals. It appears that differences between supplemented groups and groups on forage only diets at feedyard entry are largely erased by compensatory gain.

In terms of hematology surrounding the transportation of calves to the feedyard, a similar trend was seen: supplemented groups were largely the same, with forage only groups being different. HCT was significantly lower in forage only groups compared to supplemented diets in both years. Additionally, responses in white blood cell fractions was different in forage only groups compared to supplemented groups, although these responses were slightly different in each year. Forage only groups had a less responsive neutrophil reaction to the stress of transportation indicating that the innate immune system might be impaired in these calves. As these calves clearly did not perform well in the backgrounding phase, it is safe to say that they were nutritionally limited, potentially playing a role in immune response and functionality. However, in both years there was no difference between groups for morbidity or mortality.

Creating heavier calves after the backgrounding phase is a goal that any producer should strive for, especially those interested in retained ownership. Baleage, dry hay, and grazing crabgrass can all be effective forage options for growing calves when supplemented with 1% BW of DDGS. Additionally, small producers that do not have the infrastructure to handle truckloads of feed can accomplish the same results with CPC Developer feed. Forage only options have the potential to be effective, but more work is needed to optimize those diets to achieve greater gain potential.

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